SCIENTIFIC AMERICAN SUPPLEMENT. No. 1536

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Scientific American, established 1845.
Scientific American Supplement, Vol. LIX, No. 1536. NEW YORK, JUNE 10, 1905. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE NEW JUNGFRAU LOCOMOTIVE.*

By Emile Guarini.

The new three-phase electric locomotive which is now used on the Jungfrau (Switzerland) electric road is worthy of a special description, as it presents some interesting innovations in its design. The weight is 18.7 tons. It is provided with two three-phase motors, each of which can develop an average of 150 horse power. The motors make 760 R. P. M., and operate with a voltage of 450 to 600, and 38 cycles. When going up grade the locomotive has a constant speed of 8.1 kilometers an hour. In the descent, the same speed is maintained as long as the motors remain in connection with the supply circuit. But when on the down grade it is possible to run the locomotive quite independent of the overhead line and the machines in the station. A special arrangement allows of regulating the speed as desired, between a maximum of five miles an hour and a minimum which is only five per cent of the maximum speed.

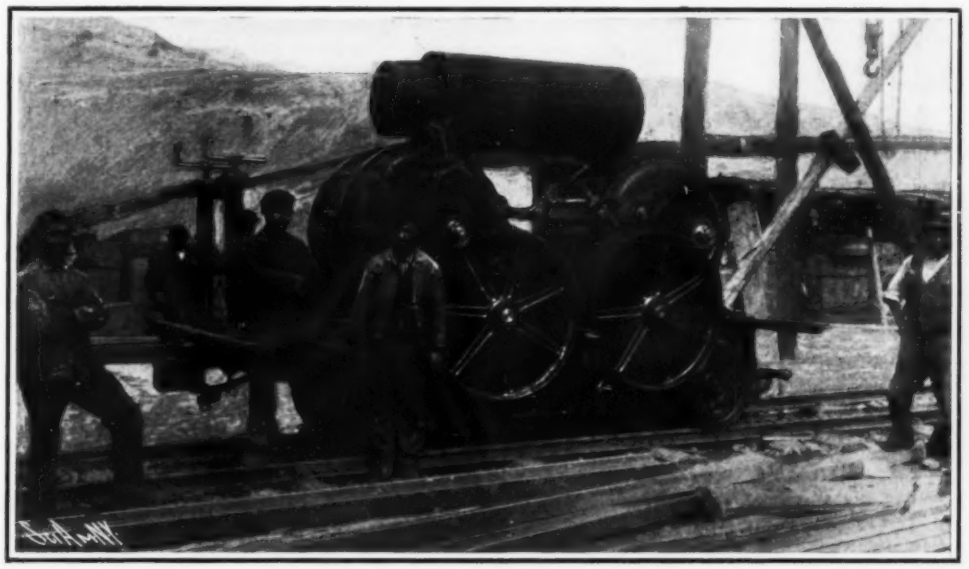
The outfit includes a voltmeter, lightning arrester, a special switch, two main circuit breakers, two ammeters, a transformer for the lamps, and a speed indicator which is run from the rear motor. The disposition of the different working parts was made the object of special study, and the designers, Messrs. Brown, Boveri & Co., Baden, succeeded in using a single controller placed on the front of the locomotive to contain the maneuver of all the apparatus, including the electric braking resistances, and in this way the locomotive can be operated as easily as an ordinary tramway car.

The locomotive is operated by a controller which contains a reversing switch for changing the direction, also the controlling device for the starting resistance and the brake resistance. The controller for the former is in the shape of a four-point switch; two points are used for reversing the car, while the motors are connected with the overhead line; one point applies the electric brakes, when the former connection is broken, while the fourth point corresponds to the stop position. In this last position the operating handle can be taken off the controller. In practical operation they use the forward movement of the car for the up grade, and the rear movement and the brakes in the descent. In the position of forward and rear movement the motors are connected to the trolley wire, and the speed of the train is about five miles an hour in both cases. In the braking position, the connection with the line is cut, and the controller places the circuits of the motor so that it works as a generator, and the resistances are then constantly in circuit with the rotors. As the generators are operated by the descent of the locomotive, they develop a certain amount of power which the resistances absorb, and this can be regulated at will. To avoid a false maneuver, the operating of the small lever of the revolving four-point switch is combined with that of the main hand which controls the resistances, so that the two will work together properly, and the switch lever cannot be displaced in the following cases: 1. With the motors running on the line, in case the resistances are in circuit with the rotors. 2. With the motors disconnected from the line, where their armatures are not as yet put in short circuit. To prevent the motorman from causing an abrupt change of speed, through negligence, while the locomotive is descending, by means of the braking resistances, a stop electro-magnet which is placed within the controller is caused to act upon the main steering wheel as soon as the current passes a certain limit caused by a too sudden lowering of the resistance. This disposition is designed to avoid the shocks which in the long run might become dangerous for the mechanism of the locomotive as well as for the rack.

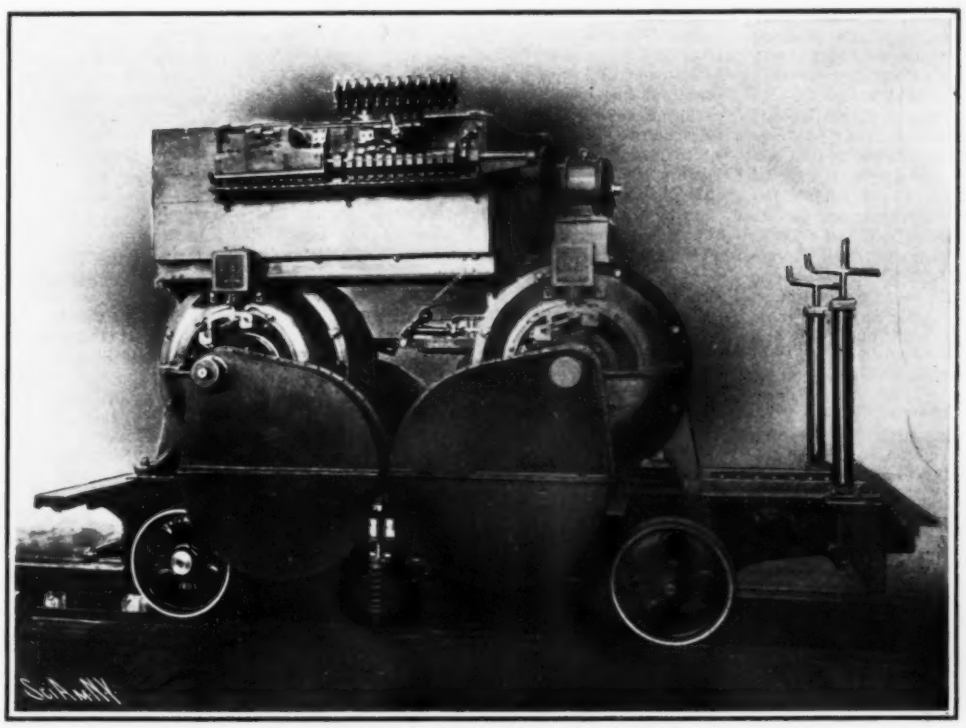
The special construction of the motors allows them to be connected so as to work as non-synchronous motors, and as generators when on the descent. To this end the rotor of the new motor is provided, on one side, with a set of three collecting rings and brushes, for inserting the starting resistances in the circuit. On the other side it carries a collector of the usual kind. When the motors are connected with the overhead line, so as to take the main current, a three-phase magnet device is operated, so as to lift the brushes off the collector by means of a series of levers adapted for the purpose. During the descent, the starting resistance can also be made to serve as an absorbing resistance for the current which the motors give when working as generators. For this purpose these resistances are designed so as to absorb about 170 kilowatts for a considerable time without undue overheating. However, as this gives rise to a certain quantity of heat, the coils are cooled by means of an air-fan, which is driven by a small three-phase motor mounted on the locomotive.

The locomotive is provided with an automatic brake, which comes into action as soon as the locomotive reaches an excess of speed equal to 10 kilometers an hour. This is a centrifugal device which acts upon the band brakes placed upon the motor axles, and at the same time operates a safety switch for cutting the motors off the line. When the automatic brake comes into play, the handwheel of the controller remains in the position which it formerly occupied, in case the motorman neglects to bring it to the stop position. In this condition it might happen that the locomotive be set in movement without having the resistances all in circuit. To avoid this, a mechanical device prevents the closing of the safety switch before the main wheel of the controller is brought to its initial position. Two hand brakes are used. One of these works upon the friction wheel of the previously mentioned brake, while the second works on a pulley mounted on the shaft of the rack pinion. The system of jaws used on the former type of locomotive for keeping the pinion against the rack is retained here.

As the above description shows, the construction of the electrical part has considerable differences from the former locomotive of the Jungfrau railroad. In designing the new type the constructors paid special attention to the fact that in the present condition of working, before it is used to draw the passenger cars, it will first be employed in transporting the material coming from the excavation of the tunnel while the latter is being finished. Allowing the trains of the hauling cars to be of ten tons weight, on an average, in excess of the usual passenger trains, this made it necessary to give a special design to some of the parts of the locomotive. These portions had to be made much more resistant than those of the former type of locomotive seeing that the pressure of the pinions on the rack is now greater than twelve tons. The new type closely resembles



THE OLD JUNGFRAU LOCOMOTIVE.



THE NEW JUNGFRAU LOCOMOTIVE.

* Specially prepared for the Scientific American Supplement.

the old as to exterior profile, the distance between the main carrying axles and the mechanical equipment, and the passenger cars are attached to it in the same way.

The former locomotives, which were built for the Jungfrau Railroad, had the same facility of remaining independent of the generating current in the descent of the track, but they had not the same advantage in obtaining such a wide variation of speed as now. In fact, the maximum speed variation was made between the normal number of revolutions per minute and one-half this number. This was obtained in the former case by making the non-synchronous motors work as generators, and the current which they furnished was absorbed by a set of resistance coils disposed to this effect. The exciting current is here furnished by a small machine which is mounted independently on the motor shaft, and this current can be regulated by a rheostat.

As stated above, in the new locomotive a different system has been adopted, which gives better results as to the limits of varying the speed. It may be remembered that the former locomotives had a weight of about 14 tons, and were equipped with two non-synchronous three-phase 150 horse-power motors running at 760 R. P. M. with 500-volt current at 38 cyles.

SUBMARINES.*

By SIR WILLIAM H. WHITE, K.C.B.

THE construction of submarines for the royal navy was commenced in 1900. Five vessels were then ordered of Messrs. Vickers, Maxim & Co., who had secured from the Holland Company of the United States the right of building vessels, similar to those which had been recently ordered for the American navy. Mr. Holland had devoted himself to the construction of submarine vessels for more than twenty years; and this continuous effort, combined with great skill as a designer, had produced gradual improvement and eventual success. When the navy department invited competitive designs for submarines it was natural therefore that Mr. Holland should prove successful. The construction and experimental trials of his vessel occupied a considerable time, but the naval commission which conducted the test experiments finally pronounced in favor of the type. Before this result was reached a new company had been formed to develop the Holland patents; and it was this company which first approached the Admiralty and subsequently arranged with Messrs. Vickers to work their patents. The Admiralty thus insured success in preliminary orders for submarine vessels; because they acquired the accumulated experience of the Holland Company and of Mr. Holland himself, with a guarantee that further improvements made in the United States during the continuance of the agreement should be placed at their disposal through Messrs. Vickers; and the resources of that firm (whose predecessors at Barrow had built a number of submarines of the Nordenfelt type) were also secured. In addition, it was decided by the Admiralty to detail an able naval officer of large experience in electrical and torpedo work to watch the construction and conduct the trials of vessels built by Messrs. Vickers, while the experience of the constructive and engineering departments at the Admiralty was made available. The strongest possible combination was thus arranged, of all classes whose co-operation tended to produce satisfactory results in the construction, equipment, and trials of the new class of vessel.

These arrangements differed essentially from those which had been adopted in France, and are still employed. The French system gives free scope to the ideas and abilities of rival designers in the Génie Maritime, some of whom have individually produced new designs before the trials of their original designs were completed. It may be thought that by thus bringing many competitors into the field superior results would be obtained; but this hardly appears to have been true; nothing like an approved type has been established as yet in France, most probably because there has not been persistence in experiment and gradual improvement with any class. As the course taken by the Admiralty was in accordance with my advice, it may be thought that I can hardly deal with the subject impartially. But that there are many advantages in the Admiralty method is unquestionable, and the wisdom of the course taken in 1900 has been confirmed by subsequent experience. Delays and difficulties similar to those which have occurred abroad have been avoided, and, in a comparatively short time, a considerable number of submarines have been built, and great and successive improvements have been effected; while as a group, British submarines undoubtedly compare favorably with any corresponding group of foreign submarines.

It is the fashion to criticise the Admiralty for long delay before beginning the construction of submarines. This criticism when analyzed will be found to be based upon misconception or incomplete consideration of the facts. No doubt French designers have shown remarkable ability in dealing with many naval problems, and they took the lead in this branch of construction largely because the conditions under which they work give greater freedom in making new departures. That lead, however, was due to special circumstances which may be noted in passing. The construction of submarines in France proceeded in a dilatory and half-hearted fashion for several years after the "Gustave Zedé" was ordered in 1888. Her trials extended over nearly eight years, and led to many modifications in details and equipment. When competitive designs for submarines were invited for the Ministry of Marine in 1896 there was no urgency or eagerness in taking action thereupon; in fact, small progress was made until an impetus to more active exertion was given by the Fashoda incident. The French people then had pressed upon their attention the relative weakness of their navy, and it was natural that consolation should be found in the distinct lead that they had undoubtedly obtained in submarines, as the result of numerous experiments. A type had been produced which was superior to all its predecessors, and could be multiplied rapidly at a moderate cost. Twenty or thirty submarines could be produced for the price of a battleship, and in much less time. Under these circumstances the cult of the submarine naturally became popular in France, especially among the members of the Jeune Ecole who had condemned the continued building of armored "mastodons," and advocated swift commerce-destroying cruisers. The development of submarines, it was argued, made unnecessary the continued construction of costly battleships; and submarines needed only to be supplemented for sea work by swift cruisers. These extreme views, however, did not represent the matured opinion of experienced French naval officers and naval constructors, and they were not acted upon. Many submarines were ordered, but the construction of battleships and armored cruisers went on concurrently, and the wisdom of that policy is now almost universally recognized in France.

Writers in the popular press of England, seeking for "some new thing" to illustrate the shortsightedness and extreme conservatism of British naval authorities, waxed eloquent in condemnation of the Admiralty for long delay in taking similar action. Underlying most of these criticisms was the assumption—which was itself a fallacy—that, if foreign navies adopted submarines, it followed that the royal navy must possess an equal or greater force of such vessels—their numbers being governed by the numbers of foreign vessels of similar type. In other words, it was tacitly assumed that submarines must constitute the best and necessary reply to foreign submarines. It may be worth stating, although the fact should be obvious, and the statement involves no breach of official confidence, that everything done in France and the United States from 1895 onward in connection with submarine construction was thoroughly well known and carefully considered by the Admiralty at the time. There was no difficulty in undertaking here the design or construction of submarines had it been considered desirable to do so; and the work of building could have been done with greater rapidity; but it was decided to await developments elsewhere before making a start. Experimental submarines had been built and tried in this country in recent years; the trials had been witnessed by officers of the Admiralty, and full information was possessed. The largest, and on the whole the best, of the submarines constructed before the introduction of storage batteries and gas engines were those of the Nordenfelt type built at Barrow-in-Furness in 1886 from designs largely due to Capt. Garrett's initiative. When it became possible to use electric propulsion for the submerged condition of these vessels, in combination with gas engines for their surface propulsion, advances could be made on the Nordenfelt type, which had been fitted with steam boilers and reciprocating engines, and consequently ran risks in diving which can be avoided under present conditions. It was no pleasure trip to go under water in a Nordenfelt vessel with boilers hermetically sealed, and propulsive power dependent upon heat stored in boilers, and in special water tanks provided for the purpose. But, while improvements in propelling apparatus had considerable effect on the design of submarines, it still remained true that this country had not fallen so much behind France or the United States as was affirmed, in the construction and trial of submarines. These experimental vessels were built by private enterprise, but the results were freely placed at the disposal of the Admiralty, and the naval service benefited by the trials. It was with this knowledge before them that their lordships took no action up to 1900; being of opinion that the time had not yet come when it was necessary or desirable to commence the construction of submarines. Nor was there in the navy itself at that date any marked or general desire for submarines; while in all other navies except the French practically the same policy of waiting was adopted. In the United States a private company, not the Navy Department, pursued the investigation to a successful issue, and official action followed. Even the French did not embark upon a definite programme of submarine construction until about six years ago, and the question is admittedly still in an experimental stage.

Many types were under consideration in France when the Admiralty made arrangements with Messrs. Vickers to build five vessels; but only a small number of submarines were ready for service in France at that time, and nearly all of these were avowedly restricted to coast and harbor defense. French official statements recently published show that up to 1897 the "Gymnote" and "Gustave Zedé" stood alone; in 1897-98 two more submarines were ordered, followed in 1899-1900 by ten other vessels of the submarine and submersible types. At the end of 1900 not more than five or six of these had been made available for service. In the United States there were then only two complete submarines, and it is interesting to note that in the United States navy at the present time there are altogether only eight submarines, although a number of vessels have been constructed there for other navies during the past year. When the Admiralty ordered five submarines of the Holland type, it was stated that the main purpose was to obtain experimental information first-hand in order to assess the true value of such vessels in naval warfare, and to determine the best means of dealing with their attacks. The latter investigation obviously must have always the greatest importance for the British navy, since no recognized authority would suggest that the British navy should depend largely on defensive weapons, or consist chiefly of submarines, even if the greatest offensive power which has been claimed for the type were realized in practice. But when other navies laid down many submarines, with the declared intention of employing them for offense and defense, it was absolutely necessary that steps should be taken to ascertain the best means of foiling such attacks, and the only method available was the acquisition and experimental use of similar vessels by the royal navy; that plan was adopted by the Admiralty as soon as the threat became serious. Action taken at an earlier date or on other lines would have involved much larger expenditure of time and money in arriving at a decision as to type. French experience, of course, could not be made available, and it was a fortunate circumstance that, at the critical moment, the Holland Company came forward, placing the British navy in a position to benefit by their experience and information, and so to start under favorable conditions on a path which has already conducted to a most satisfactory result in relative numbers and efficiency of submarine vessels under the British flag.

M. Charles Bos, in his report on the French navy estimates for 1905, gives a succinct account of the progress and present position of submarine construction in France. Starting in 1886 with the "Gymnote," the "Gustave Zedé" was ordered in 1888, and no further vessels were laid down until 1897-98, when the Morse submarine and Narval submersible were ordered. In 1899, after Fashoda, the "Français," and "Algerien" were begun by public subscription, and four submarines were included in the official programme of construction, to be followed, in 1900, by four submersibles. Fourteen vessels in all, therefore, were built and building, when the first five British submarines were ordered. From 1901 to 1904 forty-four submarines and submersibles were begun as against twenty-four ordered here. So that the totals stood at 58 for a period of 18 years in France, and 29 for five years in England, up to 1904-5. Recently the minister of marine has ordered, in addition, two large submersibles and ten submarines; against which will be set the provision that may be included in our navy estimates for 1905-6. As to submarines completed and ready for service, M. Bos states that at the end of 1898 France had two vessels, and at the end of 1901 eleven vessels, the number at the end of 1903 being eighteen vessels of 2,760 tons aggregate displacement. In July, 1904, the total of completed vessels had risen to twenty-eight. At the end of 1907 M. Bos estimates that France will possess eight submersibles of about 1,660 tons, and fifty-two submarines of 11,900 tons; or a total of sixty vessels and 13,560 tons. After a recapitulation of these facts, M. Bos observes that while "we have not ceased to alternate between large and small tonnages, there has been in England a constant progression in displacement"; thus indicating that mere comparison of numbers does not measure relative force in the vessels of submarine types possessed by the two navies. Furthermore, he states that no less than thirty months will be occupied in building each of the large submersibles just ordered, and at least eighteen months for each submarine. Statements such as these made by the reporter to the budget commission after an investigation of the subject at the outports, and after access to official documents, are worthy of note. Obviously he does not consider that the French navy possesses the enormous superiority in submarines that is attributed to it by many English writers, nor does he consider that the lead in numbers undoubtedly existing would be maintained if this country seriously challenged it.

French submarines are constructed only in the national dockyards, and there are many competing designs. Recently the hours of labor in the dockyards have been shortened, and this naturally increases the period necessary for construction; while the variety of designs in hand, containing many novel features, tends in the same direction. Labor difficulties have also occurred recently, and may have hindered progress; although it is probable that this cause of delay will only be temporary. After making full allowance for all these circumstances, it appears that the period for construction of submarines in French dockyards is undoubtedly greater than that which suffices in the private shipyards of this country or the United States. During last year a considerable number of submarines were built in the United States and sent abroad in pieces, the rate of construction having been rapid. Here experience proves that considerably shorter periods suffice for building submarines than those named by M. Bos, and it must not be overlooked that if it were considered necessary at any time to produce rapidly a large number of these vessels, the working drawings of the latest approved type built at Barrow could be sent to many other private firms, whose resources and skill would be equal to the rapid and efficient reproduction of the model vessel. While this is true, there are undoubted advantages in not building large numbers of submarines simultaneously, but proceeding gradually and ordering moderate numbers in any year, so that improvements, arising from experience and experiment with completed vessels, may be utilized, and each design brought thoroughly up to date, before it is handed to the builder for guidance. This is true not merely

* From the Engineering Supplement of the London Times.

of special features but of some which are common to submarines and other constructions. For example, the great advances being made in gas and oil engines in connection with automobiles have a direct bearing on the surface propulsion of submarines, and progress in certain branches of electricity must influence their under-water propulsion.

The alternation between large and small tonnages in French submarines, to which M. Bos refers in his report, is very notable. The "Gymnote," of 1886, was about 56 feet long and of 30 tons displacement. The "Gustave Zedé," next in order, was 159 feet long and of 266 tons. Then came the "Morse," 118 feet long, and of 144 tons, followed by the "Sirène," about 112 feet in length, and of 200 tons. In 1901 no less than twenty submarines of the "Naïade" type were ordered, 77 feet long and of less than 70 tons; and subsequently vessels of from 170 to 300 tons have been laid down, while the latest types (according to the official budget statement) are to be about 146 feet long and of 420 tons. It is reported that these are to be associated with submarines of 44 tons, smaller than any built since the "Gymnote." Speed, radius of action, and cost are varied, of course, with variations in size. No doubt one explanation of these alternations in French practice is to be found in the intention to employ the smallest types in harbor and coast defense, and to use the larger vessels on more distant service. But whatever the reasons may be for such widely-differing contemporaneous designs, the speed of construction undoubtedly is reduced. The estimated cost of the largest French submarines is about £70,000, the engines are to develop 600 horsepower, and the maximum speed (on the surface) is 12 knots. In eighteen years the length has been nearly trebled, the displacement increased fourteenfold, and the surface speed raised 50 per cent, with a correspondingly increased cost. The "Morse" cost about £26,000, and the "Français" (1901) cost about £33,000, while the "Naïade" class cost about £15,000 each.

It is a singular fact that while the progress of French submarines is recorded in publications officially authorized, and while full details of dimensions, displacement, speed, armament, etc., for vessels of the types building or projected are given in reports on French navy estimates, no similar information can be found in our own navy estimates. The contrast is all the greater because corresponding information is given for other classes of his Majesty's ships building or projected. While it is recognized that there are good reasons for secrecy in regard to many features of the design of our submarines—and especially in regard to details of mechanism or apparatus which have been improved or invented as the result of British skill and experiment—no adequate reason can be found, in my judgment, for non-publication of information similar to that published in France. Indeed, the fact that our established policy wisely keeps the construction of submarines in the hands of one firm makes it the more desirable that the public should be informed as to dimensions, particulars, and costs of the vessels ordered annually. Publicity of the character practised by the French involves no surrender of that secrecy in regard to important features in design which is undoubtedly necessary. Eighteen years' experience in France has proved this to be true. In the United States, where publicity is carried further than in France, the really essential features of designs are not disclosed. Subject to this condition it may be again asked: What reason can be assigned for the meager information afforded in our navy estimates? Take, for instance, those for 1904-5. It is stated that nineteen submarine boats are built and building; no dimensions or particulars are given; as to "estimated cost" the only remark is "details not complete"; actual expenditure to March 31, 1903, is given as £41,685—a sum which requires explanation in view of the number of vessels then practically complete. In 1903-4 the probable expenditure is given as nearly £270,000, and the proposed expenditure in 1904-5 is put at £290,000, while the remaining liability to finish these vessels is not given, the phrase "details not complete" again appearing. It cannot be supposed, however, that there are not contracts for these vessels in which the cost per vessel is agreed, or that no estimate has been made of the total liability incurred by their construction. These figures ought to appear in the estimates for the information of Parliament and the public, and such a course involves no possible disclosure of facts that would impair secrecy as to details that ought to be treated confidentially. Similarly, for the ten submarines to be begun in 1904-5, the only information furnished is that £20,000 will be spent on them up to March 31 next, and there is no indication of the total liability incurred, which is probably more than thirty times as great as this year's expenditure upon the vessels. The First Lord's statement gives a few details as to progress, saying that in 1903-4 three submarines were completed, and that in 1904-5 ten more will probably be made ready for service. Six vessels ordered previously to 1903-4 are said to have been delivered. For the reasons above stated it is most desirable that it shall not remain true that the British public are refused information which is freely given in France and the United States in regard to submarines.

As the five vessels first ordered were intended to be reproductions of the American Holland boats, particulars for them are available. The length is about 63 feet; displacement, 120 tons; surface motor, 160 horsepower (gasoline engine); speed, 8 to 9 knots; motor when submerged (electric), speed about seven knots; fitted with one torpedo tube at the bow. The contract price for each vessel in the United States was about £34,000. For later British vessels authorized particulars are lacking, but descriptions have been published from time to time from which it is apparent that considerable advances have been made in size and speed of successive types. That of which the unfortunate "A1" was the model are said to be 100 feet long, 180 to 200 tons displacement, with a surface speed of 15 knots, and a possible speed submerged of 10 knots, carrying two torpedo tubes. Later types are reported to be 150 feet long, with surface motor of 600 horsepower, and a radius of action of 500 miles instead of 300 miles in the earlier vessels. It seems, therefore, that these vessels compare closely with the largest French submarines above described; and, if so, the length has been increased about two and a half times, the displacement and power nearly four times the surface speed has been nearly doubled, and the cost probably increased in as great a proportion. No official information has been given respecting the ten vessels just ordered.

Russia is reported to have added a considerable number of submarines to her navy during the present war, and to possess 14 built and building; Japan is credited with similar action; Germany, after long delay in the commencement of submarines, is said to have six or eight built and building; Italy, which built and tried the "Delfino" many years ago and then paused in submarine construction, is again moving and is said to possess five vessels. The United States navy has eight complete. These figures show that France heads the list considerably; that Great Britain is far ahead of all other powers except France, and undoubtedly possesses the most powerful flotilla in proportion to numbers, all the units being of considerable size and of modern types.

Hitherto the offensive power of modern submarines has been limited to locomotive torpedoes. In the smallest types the torpedoes are carried outside the vessels by special apparatus, with arrangements for releasing them when desired; but in most cases torpedo tubes have been provided for their ejection. The addition of gun armaments is now contemplated. Capt. Bacon, R.N., who has unrivaled knowledge of submarines, said in a public discussion last June: "That a submarine will carry guns is as sure as there is a sky above us; the only question is how she will carry them." No doubt the gallant officer had practicable schemes in his mind when he made this statement, and the problem is not one of great difficulty from the designer's point of view, if the necessity for guns is demonstrated. But obviously such a change must involve increase in size and cost if a suitable platform for guns and their crews is to be provided at a sufficient height above water to secure efficiency in a moderate sea. Probably the suggestion arose from experience gained in maneuvers wherein submarines had been attacked by destroyers. If report speaks truth, the submarines, with their slow speed and absence of gun-armaments, were virtually helpless under many circumstances when "awash"; and even when submerged the "periscopes" indicated their locality and caused danger of destruction. Whether this be the fact or not, it is certain that to introduce an efficient gun-armament while maintaining or increasing speed, radius of action, and the power of rapid submergence must involve sensible increase in size and cost. Before steps in that direction are taken the problem will be thoroughly investigated, no doubt. Such investigation alone can show whether "the game is worth the candle." Not a few authorities are disposed to think that, taking all considerations into account, the risks incurred by swift surface vessels may be less than those taken by submarines.

(To be continued.)

ANTI-FOULING COMPOSITIONS.

ONE of the missions of an anti-fouling composition, or ship-bottom paint, is to develop after application a poisonous action sufficient to prevent the adhering of all living organisms, such as barnacles and other submarine growths. Various experiments have been made in this direction, as, for example, the mixing of arsenic with the ordinary oil-varnishes. This may be effectual to a certain extent; but the operation of grinding an arsenical color with varnish is injurious to the health of the workmen, and it is also probable that such varnish, after becoming perfectly dry, will no longer have the effect of destroying the organic growths. Paints have also been manufactured which retain a certain amount of moisture, and are thus more easily absorbed by the animal organisms. These are usually applied hot, and are preferable to the colors which become hard.

Besides being poisonous in its effect, a ship-bottom paint should be very durable, since the process of painting those parts of a ship which are under water is troublesome and expensive. Metallic oleates and sebates are the chief constituents of such paints. Some methods of preparing them are given below. Two metallic oleates, copper linoleate and copper stearate, are first prepared. The latter is mixed with the paint, which must be applied hot, and ought to remain quite soft even when dry. Another copper compound is then made from copper sulphate and lead acetate or verdigris, which serves as the poisonous element of the mixture.

Copper Linoleate.—Eighteen kilogrammes of hydrated potash or soda are dissolved in a cast-iron kettle, the solution is adjusted at 15 deg. by dilution with water, then heated to 70 deg. C., and 90 kilogrammes of linseed oil are added slowly, with stirring. The whole is then again thinned with 50 liters of water, and boiled until the soap runs clear. A solution of 55 kilogrammes of copper sulphate in 500 liters of water is prepared in a suitable vessel, and the linseed oil soap is added with stirring. The mixture is allowed to settle, the supernatant water drawn off, and the precipitate of copper linoleate well washed, filtered, and drained. The resulting thick green paste is put back into the cast-iron kettle, and heated for two or three hours at a temperature of 100 deg. C., to expel the water, then packed in wooden casks. The amount of the yield from the given quantity of materials is about 95 kilogrammes.

Copper Stearate.—Seventy-five kilogrammes of stearin are melted in a copper kettle, and a solution made of 13 kilogrammes of sodium or potassium hydroxide (18 deg. B.). The latter is allowed to run slowly, with vigorous stirring, into the melted stearin, and the stirring is kept up till the soap is quite clear. Fifty-seven kilogrammes of copper sulphate are dissolved in another vessel, and the stearate is precipitated on the addition of the stearin soap. It is best inspissated by putting it gradually in a kettle and evaporating the water. Like the copper linoleate, it is kept in wooden casks.

Verdigris.—Sixty kilogrammes of crystalline sugar of lead are dissolved in a copper kettle, poured into shallow copper pans, and well stirred together with 40 kilogrammes of finely pulverized blue vitriol. A very tenacious mass is formed, and allowed to cool, after becoming even in consistency. It is removed from the pan with copper spatulas, spread upon boards to dry, and ground in a closed vertical mill. In grinding verdigris, which is well known to be extremely poisonous, the workmen should be well protected by respirators.

A paint suitable for ship bottoms is made by mixing the above-named metallic compounds with lithopone or zinc white and heavy spar in different proportions, and grinding the mixture with a good oil varnish. If it is desired that the paint should be hard when dry, some saline solution is added.

Hard Ship-bottom Paint.—(1) 30 kilogrammes of copper linoleate, 25 kilogrammes of lithopone, 10 kilogrammes of heavy spar, 30 kilogrammes of oil varnish. (2) 30 kilogrammes of copper linoleate, 15 kilogrammes of zinc white, 10 kilogrammes of lithopone, 30 kilogrammes of varnish, 5 kilogrammes of a resin solution. (3) 25 kilogrammes of copper linoleate, 25 kilogrammes of verdigris, 10 kilogrammes of white lead, 10 kilogrammes of heavy spar, 30 kilogrammes of varnish. (4) 25 kilogrammes of copper linoleate, 25 kilogrammes of verdigris, 30 kilogrammes of varnish, 3 kilogrammes of a saline solution.

For a Soft Paint.—(1) 25 kilogrammes of copper linoleate, 15 kilogrammes of copper stearate, 15 kilogrammes of lithopone, 20 kilogrammes of varnish. (2) 30 kilogrammes of copper linoleate, 10 kilogrammes of copper stearate, 10 kilogrammes of lithopone, 5 kilogrammes of verdigris, 15 kilogrammes of varnish. (3) 15 kilogrammes of copper linoleate, 15 kilogrammes of verdigris, 5 kilogrammes of copper stearate, 5 kilogrammes of lithopone, 12 kilogrammes of varnish.

A harder or softer paint can be made by altering the proportions, and it can be made more or less poisonous by using a greater or less quantity of verdigris. It may be remarked that the mixtures given above have been tried with good results. Most essential are the metallic oleates. The same results would doubtless be obtained by following these directions on a larger scale.—Farben Zeitung.

MAT VARNISHES.

THE fact that dead or dull varnishes are coming more and more into use cannot have escaped the observer of the varnish industry. But their manufacture, equally with that of the other varieties, is also becoming more difficult, on account of the enormously high price of the crude materials. Beeswax, which has been, to a certain extent, indispensable to the process, is constantly rising in price. The varnish manufacturers find themselves forced to seek a substitute. The results of such experiments have not come very much into public notice, and an account of my own attempts in that direction may not be uninteresting.

I obtained a fine white mat or dull varnish by the following method: One hundred parts of wood-oil were heated to 180 deg. C.; there were then added 4 parts of manganese resinate, the mixture was boiled one hour and left standing several days. A siccative was prepared from 100 parts of resin, 9 parts of lime, 10 parts of thick linseed oil, 20 parts of lead linoleate, 150 parts of oil of turpentine. Seventy-five parts of the prepared wood-oil and 25 parts of the siccative are thoroughly mixed. This varnish becomes perfectly dry in twelve hours, and is a very fine white.

The prepared wood-oil applied alone gives a hard and a very beautiful white coating, but the dull surface has the appearance of marble. With the siccative, we obtain a surface exactly resembling that of an eggshell, and very much liked. The greatest care is necessary in the preparation of the wood-oil, since the quality of the product is extremely variable. It is always best to experiment with small quantities first.

A good black dull or lusterless varnish: 2 parts of Syrian asphalt, 20 parts of oil of copal, 20 parts of thick varnish oil, and 40 of oil of turpentine. When the asphalt is thoroughly melted, the copal oil is added, and the mixture is boiled until the water in the oil is evaporated. It is then allowed to cool, and the varnish oil and turpentine oil, well stirred together are added. This varnish dries slowly, but if 5 parts of fine lampblack are added, it dries with amazing rapidity, in from four to six hours, and is a deep, dull black.

Inexpensive dull black varnish: 2 parts of dark resin, 1 part of lime, 6 parts of thick varnish oil, 20 parts of

Thuringian asphalt, 20 parts of turpentine oil, and 20 parts of benzol. The resin is hardened by the usual methods, the varnish oil and the asphalt added, and the whole heated to 260 deg. C. It is then cooled, and thinned first with the turpentine oil, and then with the benzol. The liquids must be added very slowly, in a small stream, with vigorous stirring. The more painstaking this process, the finer the grain of the varnish.

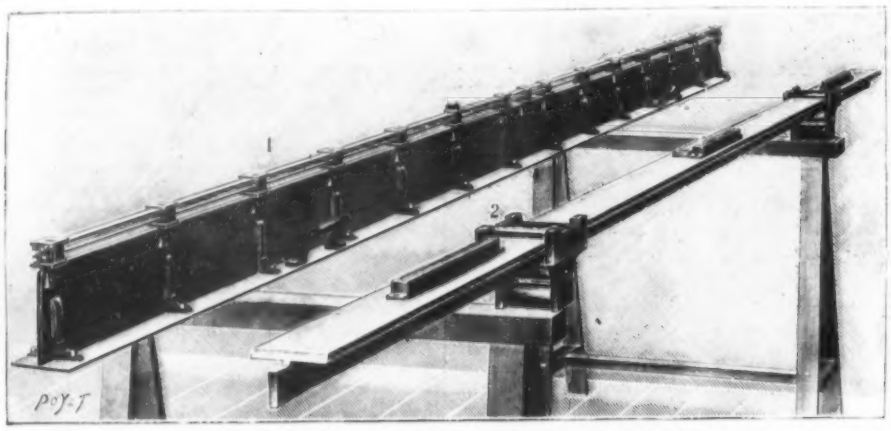


FIG. 1.—THE BRUNNER AND THE BROCH BIMETALLIC RULES.

Brown spirit varnish (dull): 20 parts of soft Manila copal (spirit soluble) dissolved in 35 parts of alcohol, and 20 parts of mineral shellac (acaroid gum) dissolved in the same quantity of alcohol. After each solution has settled, the two are mixed.

White mat spirit varnish: 20 parts of the best quality of light Manila copal, dissolved in 35 parts of alcohol, the solution allowed to settle, and well mixed, cold, with 20 parts of collodion.

Black mat spirit varnish: 19 parts of the above-described brown spirit varnish mixed with one-quarter as much aniline black, and 1 part of the finest lamp-black ground in 2 parts of alcohol.—Farben Zeitung.

MODERN GEODETIC RULES.

THERE is no measurement of precision that is not rendered more difficult and uncertain by the expansion of the rules and other apparatus used in the operation. In no domain are the disadvantages of expansion so apparent as in geodesy, and that for reasons that will become evident after we shall have pointed out the practical problems with which this science has to deal.

The starting point of every geodetic triangulation consists of a base a few miles in length, limited by two monuments and forming the first side of the entire chain of triangles with which the territory of the country will be subsequently covered. Upon the accuracy with which this base is measured depends that of the entire future work, namely, the numerical values of the distances and surface areas in the entire country, and the figures of the curvature of the earth in the vicinity deduced therefrom by means of astronomical observations, and, in short, all the topographical or geodetic data that triangulation is called upon to furnish.

The process of measuring bases has varied greatly in the course of time, but the modifications introduced into the operation by geodeticians relate only to details of execution, the principle always remaining the same. A standard rule is laid down, end to end, for a certain number of times from one end of the base to the other and thus it fixes the position of a series of marks, and the sum of the distance of these movable marks, determined by means of the rule, gives the length of the base. If the rule were invariable, the entire difficulty of the measurement would consist in obtaining the sum of the distances of the marks. But experience has shown that while this measurement is most easy and certain, the variations of the rule caused by the incessant changes of temperature constitute the greatest obstacle to the accurate measurement of bases. In fact, whatever be the precautions taken for determining the temperature of the rule, under variable atmospheric conditions, there remains some little uncertainty, which reacts upon the results; and such uncertainty has engrossed the attention of engineers to such an extent that the history of the measurement of geodetic bases during the last century might almost be summed up in that of the precautions taken to assure a perfect determination of the temperature of the rules.

A rapid enumeration of the instruments employed for a century past in the measurement of bases will show well to what an extent this question of temperature has occupied the attention of geodeticians. At the epoch at which was projected the great work that was to give the world its universal system of measurements, Borda and Lavoisier devised the bimetallic rule consisting of two bars, one of brass, and the other of platinum, superposed and carried by a wooden beam surmounted by a protective covering. The difference in length of the two rules was taken at every instant as an index of their temperature supposed the same, and such temperature being thus supposed known, the length of the platinum rule was deduced therefrom.

Therefore, at an epoch at which the method of working platinum was scarcely known, and at which its agglomeration into a compact mass was an extremely difficult operation, it necessitated considerable complication to make use of the relatively slight expansion that this metal undergoes, and the construction of the fundamental instrument for the measurement of bases was sensibly complicated in the hope of slightly increasing the accuracy of the accessory determination designed to make known the temperature of the rule.

The direct superposition of the bands of platinum and brass in the Borda and Lavoisier rules presented some drawbacks, the most sensible of which consisted in frictions, which prevented the rules from expanding freely, and which could not fail to vitiate the measurements somewhat. It must not be forgotten, however, that the illustrious geodeticians of the epoch of the Revolution did not try to obtain the accuracy that is reached at present. They pronounced themselves as perfectly satisfied when a measurement of length had been made with an accuracy of a hundredth of a line, that is to say, about two one-hundredths of a millimeter; and it really seems that their rules, manipulated with that extreme skill that they introduced into their operations, admirably seconded by a consummate good sense, must have given them, on an average, a precision at least of this order. Some verifications made subsequently by MM. Benoit and Guillaume at the International Bureau of Weights and Measures have shown that, in effect, the meter was deduced from one of the rules of Borda with surprising accuracy.

Nevertheless, the increasing exigencies of geodesy led to the improvement of the Borda and Lavoisier rules, with a retention of the principle of their construction, and the result was the production of the four celebrated instruments of the brothers Brunner, that were acquired by France, Germany, Spain, and Egypt. Fig. 1, No. 1, represents one of these. A strong iron girder supports, through the intermedium of a series of rollers, two rules, respectively of brass and platinum, superposed at a slight distance from each other, and so arranged as to make it possible to measure at every instant the difference in their lengths, reckoned upon small scales in juxtaposition in a window formed in the platinum rule. The Borda rules had a length of 2 toises (12.789 feet), while those of Brunner were 4 meters (13.12 feet). They are heavy and delicate instruments, which are difficult to handle, but which, thanks to the skill and devotion of those who have had to make use of them, have given very satisfactory results in the four countries that possess them.

The rule represented in the figure was used for measuring the three principal French bases, and has just been brought back from Ecuador, where it permitted of measuring a base upon which was begun the triangulation of the arc of meridian formerly measured by Bouguer and La Condamine and which is being measured at present by officers of the geographical service with all the requirements of modern geodesy, while daily surmounting the greatest difficulties imaginable.

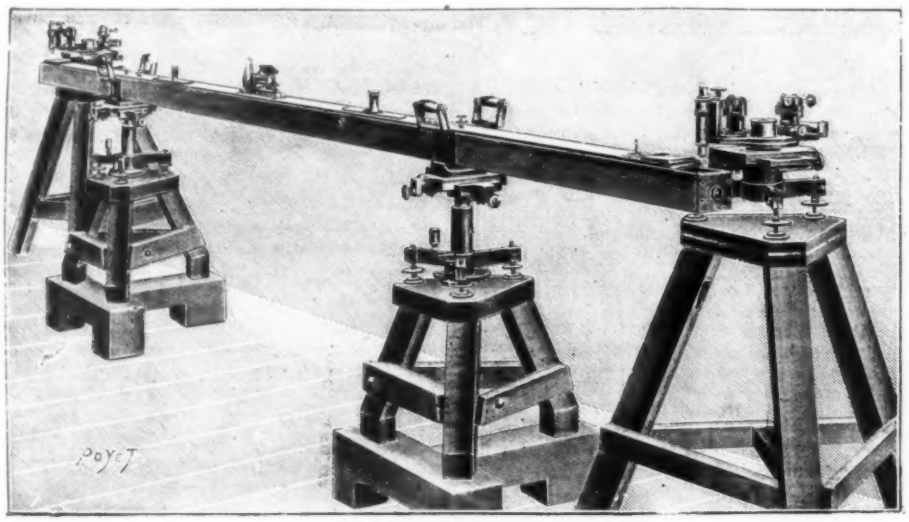


FIG. 3.—THE RULE UNDER THE MICROSCOPE.

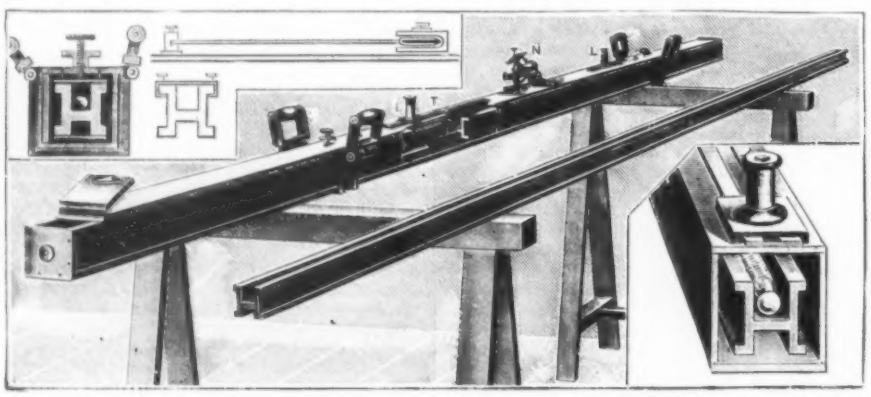


FIG. 2.—THE INVAR RULE AND ITS BOX, AND A PART OF THE RULE WITH A THERMOMETER.

In addition to bimetallic rules, those of a single metal, accompanied with thermometers, have remained in use and still constitute the majority of the present geodetic standards. Gen. Ibañez was the first to return to these by having the Brunner brothers construct an iron rule quite similar to the support of the preceding bimetallic one.

Later on, Dr. Broch had the iron rule shown in Fig. 1, No. 2, constructed. This, as may be seen, is provided with large rollers, designed to give it free play upon its support, and three thermometers for measuring its temperature. Three of these rules have been constructed, one for Sweden, one for Norway, and one for the observatory of Montevideo. The one shown was used in the great Suedo-Russian expedition to Spitzbergen, and upon its return to the International Bureau found a place alongside of the Ecuador rule. In this manner, it was possible to compare these two rules immediately after the fundamental operations in which they had been employed, so as to assure a perfect unity in these two measurements combined, designed to make better known the form and dimensions of the globe. It may be added that the bimetallic rule of Egypt was included in the same comparisons, so that, besides the extreme latitudes, the mean ones also have participated in the same revision.

In the United States, engineers have proceeded with that energy which characterizes all American enterprises. They have not been content to measure the temperature of the rules, but have desired to obtain a fixed temperature, and, in operations upon land, the rule is buried in broken ice. Such a solution of the question is doubtless excellent, but the complication of the work is extreme.

These examples show how greatly the material for the measurement of bases would be simplified if the rule were constructed of a metal that did not expand

or of one that expanded so slightly as to allow the measurement of its temperature with the required precision to become an elementary operation necessitating no complicated arrangement.

On the other hand, during the course of the long studies undertaken at the International Bureau of Weights and Measures upon geodetic rules, and in which MM. Benoit and Guillaume were associated, almost every one of the rules employed in the great work performed for more than a hundred years back passed through the hands of these gentlemen, who were thus able at their leisure to note their respective merits or demerits, and who were led to form a project for the construction of a rule free from the defects of the existing instruments, when the advent of invar gave their ideas a more precise turn. In 1898 Gen. Bassot, who had closely watched the work of MM. Benoit and Guillaume, had them construct for the geographical service of the French army a rule conformable to their projects, and which we shall describe.

Let us say in the first place that a good rule should suffice of itself and ought not to be dependent upon a determinate support, on which it rests, and from which it cannot be separated without being in danger of changing length. It ought therefore to be formed of a bar so rigid as to undergo but slight flexions when it is supported by only two of its points, properly chosen. Were such the case, it would be possible for the rule to be carried independently of the support upon which it rests.

This consideration led MM. Benoit and Guillaume to give to the rule constructed by them (Fig. 2) quite a wide section, inscribed in a square of 40 millimeters (1.56 inch), but hollowed out in such a way as to lighten it as much as possible, while at the same time the plane of the neutral fibers was exposed. Conformably to European practice, the rule is 4 meters (13.12 feet) in length, and its rigidity is such that when it is placed upon its normal points, its total pitch is but 0.6 millimeter (0.0234 of an inch). Such pitch is counterbalanced by the construction, and the surface carrying the divisions remains straight when the rule is placed upon its two points of support defined by the minimum condition of flexion. The rule is inclosed in a very strong yet very light aluminium box, which protects it alike from shocks or dust and against too rapid

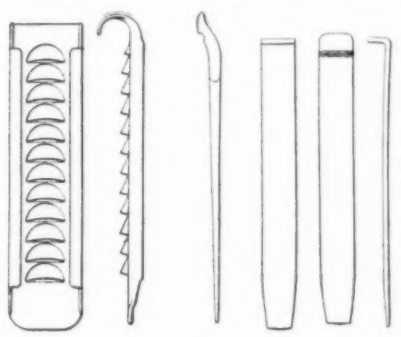


FIG. 2. FIG. 4. FIG. 5.

variations in temperature. In fact, although the rule is of invar, it has not been possible to obtain in so voluminous a piece a zero of expansion; and MM. Benoit and Guillaume have had to be content with what industry could furnish—an alloy of very slight expansion; and have assured themselves of arrangements that permit of measuring the temperature with an amply sufficient precision.

In the hollow of the rule are placed two thermometers in very perfect contact with the metal and which closely follow the variations in its temperature. Windows formed in the cover of the box and closed by panes of glass permit of reading the thermometers, *T*, by means of the spy-glass, *L*. Not far from the extremities and at the exact distance of 4 meters (13.12 feet) the rule is provided with extremely fine lines to be pointed upon the ground with two microscopes constituting two instantaneous marks of the base. Fig. 3 represents this operation. The rule, inclosed in its box, is placed upon two regulatable supports. The microscope, which also is provided with regulatable parts, points toward the rule, the extremities of which alone are uncovered. Each individual operation thus increases the length of 4 meters (13.12 feet) measured from the first extremity of the base. The instrument as a whole is nothing more than a movable comparing-rule that is destroyed at the rear and reconstructed in front by alternately displacing the two microscopes.

The rule and its box are independent of each other, since they are in contact only at two points situated above the beams through which the box rests upon its supports, and which serve to raise it in carriages by hand. It is therefore possible to separate the rule from its box without any danger of injury from mechanical stresses. The apparatus is relatively light as compared with the old ones. Thus, while the Brunner rules weigh 72 kilogrammes (158 pounds) without any protection, the new instrument inclosed in its box does not exceed 56 (123 pounds); and, since the entire instrument is strong and of small section, it is easily transportable.

The new rule has been favorably received by geodetic engineers, and MM. Benoit and Guillaume received orders to construct instruments for the geodetic services of Japan and Mexico, as well as for the service of weights and measures of Germany and Russia. These rules were forged and rough-shaped in the steel works of Imphy and finished in the shops of the Societé Genevoise. The manner in which the difficulties of the construction were surmounted and the perfection attained in the finishing of them reflect the greatest honor upon the works and shops that had to do with their making.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE "HELENA" TIRE-TOOL KIT.

THE "Helena" tool kit, designed for the use of automobilists, contains a set of tools for the quick and easy

FIG. 1.

dismounting and mounting of pneumatic tires. Fig. 1 represents the kit open, and the tools in place. Fig. 2 shows, in plan and section, a rack adapted to be hooked to the clincher rim, and having notches for giving a purchase to various levers. Fig. 3 represents a slide upon which rests the edge of the tire during the mounting. Figs. 4 and 5 show the set of levers used in the process of mounting and dismounting. Fig. 6 shows the slide provided with a parchment-covered leather strap, and a hook secured by two screws that permit of its displacement. Fig. 7 represents the slide provided with a hook for the purpose of withdrawing the valve.

We shall now endeavor to show how these various appliances are used. Let us suppose that a tire has become deflated while in the garage, so that the machine has not been run with the tire deflated. The tire, especially if it has been mounted for a long time,

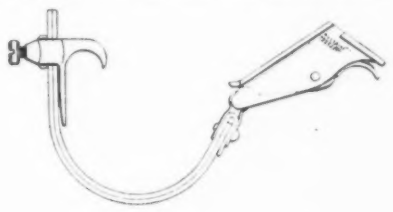


FIG. 6.

will be difficult to loosen from the rim. Fig. 8 shows the method of using the slide provided with the strap and hook, regulated once for all according to the width of the rim. The operation is easily performed. It suffices to place the hook upon the internal side of the rim and move the slide along the rack by means of the strong lever, which latter exerts upon the tire a pressure that loosens it from the rim, and permits the dismounting levers to be easily slipped under. Such an operation is generally useless after the carriage has rolled upon the deflated tire, since the edge is then sufficiently loosened.

The edge of the tire, on the external side, being entirely out of the rim, it now becomes a question of extracting the tube of the tire, which is generally an easy operation as far as to the valve; but, since the latter is in most cases quite long, its extraction, despite the use of levers manipulated by an experienced hand, is sometimes difficult and often disastrous to the threads on the valve stem or to its other parts. Fig. 9 shows how easily the operation may be performed with the "Helena" hook, which may be used also for replacing a tube.

Let us now see how a tire is remounted. If it is a

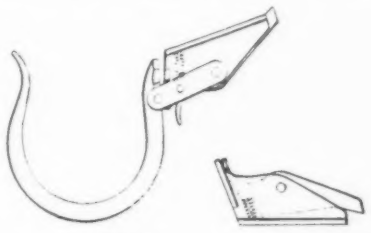


FIG. 7. FIG. 8.

new shoe which is to be put on, the operation, which is so difficult to perform, even by experts, despite the ordinary levers, becomes child's play to an amateur possessing a "Helena" kit. Upon the lower part of the circumference of the rim is placed all that part of the shoe that can be set in the rim by hand without any trouble. Then the three "Helena" racks and the strong lever are brought into play, and the tire will take its place of itself in the rim, without displacing itself by the least fraction of an inch. Fig. 10, which shows the operation of remounting the external edge in the rim, may serve to explain how a new tire is put in place, the sole difference being that the force of the lever is here exerted upon the internal edge of the tire. —Translated from L'Automobile for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE WORK DONE BY THE RADIATOR ON A GASOLINE AUTOMOBILE.

THE true importance of the radiator in its relation to the petrol engine is not only underestimated by the lay owner of an automobile, but even some engineers and manufacturers appear to have little conception of

FIG. 8.

the function of this feature of the power system of a motor-car and the best form of construction to result in the greatest efficiency. A test made by the writer on a well-built, high-speed engine showed the percentage of heat units the radiator is compelled to throw off in proportion to the work performed to be as follows:

	Per cent.
Turned into work	30
Taken up by the water jacket	40
Escaped through the exhaust	28
Loss by direct radiation	02
	100

This test was made on a 24 brake horse-power en-

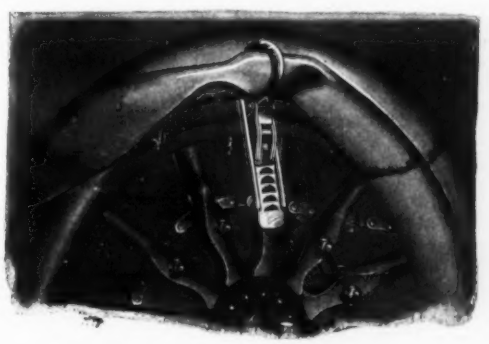


FIG. 9.

gine, using 0.6 pound of 0.72 degree spirit per horse-power per hour. The engine being exceptionally well proportioned and made, the fuel consumption was very low; on other tests made the fuel used ran as high as 1 pound to 1½ pound per horse-power per hour, in which case the water had to carry off more heat units. Gasoline having 11,000 heat units per pound was used, and as 6 pounds was consumed, 66,000 heat units were generated, 40 per cent of which went to the water jacket, making 2,640 heat units per horse-power per hour for the radiator to take care of. Therefore, with a full load of 24 horse-power there would be 63,360 heat units per hour for the jacket water, while in an ordinary or inferior construction the work of the radiator would easily be double.

FIG. 10.

The temperature of the jacket water is another very important factor, as in a series of experiments it was found that a saving of 8 per cent in gas consumption per brake horse-power was made by raising the temperature from 60 deg. F. to 140 deg. F., 12 per cent by raising it from 60 deg. to 170 deg. F., and 15 per cent by raising the jacket water from 60 deg. to 200 deg. F., at which point the engine showed the highest efficiency. It has been fully demonstrated by practical experiments that with the jacket water a few degrees below the boiling point the engine gives the highest efficiency, while the difference in temperature between

the inlet and outlet should be the least possible; this difference can be brought to a minimum by the proper proportioning of the radiator and the flow of the water, bringing a more even temperature to all parts of the cylinder wall, and resulting in the greatest economy in fuel consumption and a greater efficiency by producing less friction through expansion and contraction.

Copper is the best material to use in the construction of a radiator, as it is the best conductor of heat of any of the several metals suitable for the purpose. The tubes, whether flat, round, rectangular or polygonal, should be of the thinnest gage possible, the object to be attained being the rapid transmission of the heat units from the water to the outer air, which a thick wall hinders, owing to the comparatively slow passage of the heat through the metal. Thick walls in the tubes also reduce the area of the wall in contact with either the water or the air.

To obtain the best result the volume and velocity of the air passing through the radiator have also to be considered. The tube walls being very thin, and transmitting a large number of heat units, it is very important that the volume and velocity should be in such proportion as to carry off a certain number of heat units, but no more, as a surplus of air would occupy valuable space, which should be utilized to gain efficiency and reduce the water supply necessary to properly cool the engine. For illustration, a tube one inch in diameter or one inch square would allow a volume of air to pass through the center that would not perform any function whatever. Having so large a volume, the velocity of the air would not be great enough to carry off the heat units supplied to the air in contact with the thin metal, while at the same time a large volume of air would pass through the center of the tube too rapidly to absorb any of the heat.

The writer and his associates have conducted a large series of experiments under all the conditions to which a radiator is subject, and have demonstrated to their satisfaction the proper proportions of air volume and velocity to gage of metal to produce the highest efficiency while occupying the least space, and requiring the smallest quantity of water.—The Automobile.

A BRIEF STUDY OF THE FERRO METALS AND THEIR ELECTRICAL MANUFACTURE.*

By AUGUSTE J. ROSSI.

WE intend in the following to describe in a succinct manner the methods followed in the manufacture of ferro metals in general, mentioning their properties and uses, but specially to submit the result of four years of study of the last comer, ferro-titanium, not so well known in this country as it appears to be in Europe.

Of these ferro alloys some have been known for many years; others have been introduced into use at a more recent date; others still are quite new, either on account of the scarcity of the ores from which they are obtained or because of special difficulties or cost of reduction, only surmounted lately. The development of electrical science in the last twenty years has been such that even certain of these ferros, formerly manufactured in the blast furnace, have been smelted by electrical processes, and this method has proved to be more economical than the one previously followed, so that they really come within the scope of this article.

FERRO-MANGANESE.

Spiegel and ferro-manganese and their use in the steel industries have been too well known for years to deserve more than a mention. Their manufacture has been and is yet carried on regularly in the blast furnace with perfect success. However, certain manganese ores, known under the generic name of "wad," and found in Canada and elsewhere, covering large tracts of land, occur in a physical state which has rendered their treatment in the blast furnace unprofitable. We have this year smelted electrically this class of ores by a special electric method. They yielded an excellent ferro, and such smelting, if properly carried on, will certainly prove economical whenever and wherever such ores can be obtained at a nominal cost, practically that of digging them, and where the electric current is available at favorable figures.

Ferro-manganese, or spiegel, used in the steel industry for recarburizing, introduces into the finished product but a small percentage of manganese—say, from 0.20 to 1 per cent, more or less. Special steels containing as much as 12 to 14 per cent of manganese, known as "manganese steels," have more lately received industrial applications. The work of Mr. Hadfield in this line is classic, so to speak, and we cannot do better than to refer the reader to the masterly papers he or others have published on this subject.

FERRO-SILICON.

There is another ferro which has been known for years, and which also can be manufactured in the blast furnace, at least up to percentages of silicon of 12 to 14 per cent or thereabout, but above these figures the electric smelting of ferro-silicon up to 50 per cent or more of silicon has proved more economical—in fact, it is the only method which could insure success. The uses of this ferro in the metallurgy of iron are too well known for us to insist upon them. It has received also other applications.

FERRO-NICKEL.

This is another ferro of which the use in the manufacture of steel has stood the test of years' experience for armor plates, boiler plates, and kindred or other purposes, but the metal itself can be readily obtained now from its ores by metallurgical treatment other than electrical, and as nickel is most generally introduced in the steel as a metal it does not properly come within our province to do more than mention it. We should add that so far as nickel or any other metal is concerned and mentioned as electrically obtained, it is not the intention to consider electrolysis. If advisable and economical, however, under special conditions ferro-nickel could also be smelted electrically.

OTHER FERROS.

The ferros to be referred to specially are the alloys of iron with metals whose occurrence in nature is rarer. Such are ferro-chrome, ferro-tungsten, ferro-molybdenum, ferro-vanadium, and particularly ferro-titanium. Although the ores of the latter are abundant and cheap, it is but little known.

The rarer metals are met in nature most frequently in the state of oxides associated with oxides of iron, in an earthy gangue. Very often these ores, being too poor, must be concentrated so as to eliminate as much as possible the non-metallic elements. These concentrates, unless the ores themselves prove to be rich enough, form the real raw materials of the manufacture of ferros. Titanium occurs in many iron ores as titanic oxide, frequently to the extent of 10 to 40 per cent and more, and is also met in nature as rutile, which contains 85 to 95 per cent of titanic acid, the balance being chiefly oxide of iron.

REDUCTION OF CARBON.

Metallic oxides may be reduced to their metallic elements by two different methods. First, by carbon in some form, in which case the ferro obtained contains always a lesser or greater percentage of this element (above 1 per cent and up to 8 per cent or more). Even an additional subsequent electrical treatment of the product does not remove it below 2 per cent, if to that. They may also be reduced by aluminium, whose property as a reducing agent of oxide compounds has been known as a laboratory fact for the last fifty years or more. The great heat of formation of aluminium oxide (alumina) causes the aluminium to oxidize at the expense of the oxygen of the compound. By this second method the ferros obtained are practically free from carbon, containing less than 1 per cent.

The first method (by carbon) can be carried on in the blast furnace. This is true for ferro-manganese and ferro-silicon, as we have seen. It is even so for ferro-chrome, which has been made in the blast furnace, up to 60 per cent chromium, at Unieux (France); but the oxides of tungsten, vanadium, molybdenum, and especially titanium, are not reduced to any practical extent at the temperatures prevailing in the blast furnace, though their reduction is readily secured in the electric furnace.

The creation of large electric power plants, or of more modest plants in favored localities, has rendered electric current available at reasonable and even advantageous rates, and this electrical treatment is perfectly practical and industrially economical. It is more particularly so for such ferros as ferro-silicon (above certain percentages of silicon), ferro-manganese under special conditions as to ores, and for ferro-chrome, than is the blast furnace smelting.

FIRST METHOD—REDUCTION BY CARBON.

Electric furnaces vary considerably in their details of construction, and also in the mode of application of the current, but one of the dispositions frequently adopted as the most practical—certainly the simplest—is the following: The electric furnace consists essentially of a masonry of graphite, agglomerated with and incased in an iron or cast iron shell or box connected at the bottom with one of the bus bars of the current, and forming the anode. In this masonry there is a central cavity forming a crucible or hearth, the dimensions of which are determined by the quantity of material to be heated in one charge, the quantity being dependent upon the intensity of the current available. A pencil of carbon or a bunch of several pencils, as the case may be, of an area determined by the amperage used, forms the cathode or positive electrode. This carbon is counterbalanced by proper weights, and is so supported that it can be moved vertically up and down in the center of the cavity or hearth, leaving ample room between the sides of the hearth and this electrode. This motion is obtained either by hand, with proper pulleys, chains, and winch, or automatically by appropriate electrical devices. This carbon pencil is connected by proper contrivances, such as flexible cables, with the other bus bar of the current. A lowering or raising of the carbon pencil causes the arc to start between the charges as they are gradually fed around it in the hearth and the bottom of the furnace forming the anode. Generally the arc is started first between the pencil of carbon, the cathode, and the anode (the bottom of the hearth), and the materials are gradually charged until the furnace is about half full. The operation of reduction proceeds and fresh charges are added at proper intervals, according to current and the composition of the ores. The time of casting will, of course, vary. When enough ferro alloy has been obtained the furnace is tapped at a proper opening, provided at the bottom of the hearth, and the charging is resumed gradually at regular intervals until the next cast. The charges consist of an intimate mixture of the concentrates or of rich ores and of carbon in some form (charcoal, coke, anthracite), both materials being in the state of coarse powder. The arrangement of the furnace is that of the typical Siemens electric furnace of 1879. Many patents have been secured for different arrangements of the electrodes and of the other parts of the apparatus, but as an arc furnace this Siemens disposition appears to be the simplest and the most effective. The current used can be continuous or alternate. The furnace may be round or square. It may be closed at the top with special devices, such as plates, cooled by a circulation of water. The pencils of carbon forming the cathode may also be provided with a head in which circulates water. The feeding, when the furnace is closed at the top, may be performed automatically with a worm and gear. The main features, however, remain the same and the various improvements adopted aim to avoid as much as possible any loss of the heat supplied by the current or its utilization after it has secured the desired reduction of the oxides, and to reduce to a minimum the wear and tear of the electrodes or of the furnace itself, and thus diminish the cost of production.

In this manner we have made or seen made ferro-chrome, with 65 per cent chromium or more; ferro-silicon, with 45 to 50 per cent silicon; ferro-molybdenum, from molybdenite (a sulphide of molybdenum with more or less iron; in this latter case the sulphur was removed from the compound of carbon instead of the oxygen); ferro-tungsten, with 76 to 78 per cent tungsten; and ferro-titanium, with from 4 to 75 per cent titanium or more.

All these ferros contained from 3 to 8 per cent of carbon, excepting ferro-silicon, since carbon appears to be excluded from the alloy by silicon. These carbon alloys are not, as a rule, so well adapted to the treatment of steel as others practically free from carbon. Their cost depends greatly on the price paid for the concentrates or the ores. While good chrome ore costs only $25 per ton, wolfram concentrates (oxide of iron and tungsten with 65 to 70 per cent of tungstic acid) cost as much as 8 cents per pound, while vanadic concentrates and molybdenite are rated at least at 50 cents and 45 cents per pound. As regards ferro-titanium for seasoning cast iron by the addition of 1 to 2 per cent of a 10 per cent alloy, the presence of carbon in the ferro is of no consequence, and therefore, since it may be reduced by carbon, its cost is considerably lower than that of the other carbon ferros mentioned, excepting possibly ferro-silicon. Titaniferous iron ores of a composition capable of yielding ferro-titanium containing from 10 to 35 or 40 per cent of titanium do not cost any more than ordinary iron ores, and even less. We may add that on this score of cheapness of raw materials ferro-titanium proves the cheapest to manufacture of all the ferros mentioned above.

These titaniferous ores are found nearly all over the world—in some localities in the Adirondacks, New York, and other States of the Union; in Norway, Sweden, Russia, and Canada, in mountain masses. They are most generally free from injurious amounts of phosphorus and sulphur (below the Bessemer limit). Titanic oxide, or titanic acid, as it is also called, is met also in nature as rutile, containing from 85 to 95 per cent titanic acid and more. Recently it has been found disseminated through a rock formation in Virginia, permeating the rock to the extent of giving it a purplish color. A water concentration will readily yield the rutile as high as 90 per cent in titanic acid, and more, the balance being mostly iron oxide. In the event of a proper demand it could be supplied, it is said, at very reasonable rates. Of course rutile can be reduced by carbon directly by the method described above, but for reasons that are to be referred to further the much cheaper titaniferous iron ores are preferred—at least for alloys in which the presence of carbon is not objectionable.

At any rate, were the price of rutile to prove an item of importance when ferro-titanium free from carbon is desired, and were titaniferous iron ores to be too low in titanium for the very high percentage of titanium desired in the ferro, above 40 per cent titanium, for instance, then an "artificial" rutile, an igneous concentrate of titanic acid, can be made by a special method. Applied, for instance, to an iron ore containing, like the Adirondack ore, 58 to 60 per cent of iron (metallic), 15 per cent of titanic acid, and some 3 to 5 per cent of gangue, the method consists, briefly, in reducing electrically only the oxide of iron of the ore by adding carbon in quantity just sufficient to do so but no more, and applying a moderately intense current. Pig iron is obtained, and the slag accompanying it contains practically all the titanic acid of the ore with no or but very little oxide of iron. As much as 70 per cent of titanic acid, and even 80 per cent and more (using other ores), has thus been found in this "igneous concentrate," as we have called it; it is, in fact, an "artificial rutile."

The pig iron produced has the special qualities of the metal obtained in the blast furnace from the smelting of titaniferous iron ores, and, as such, it commands a price which offsets the expense of the concentration, so that it is possible to secure at a nominal or no cost the raw material "rutile," with which alloys of any percentage of titanium can be made by the carbon method, or which can be advantageously used for reduction by the aluminium method. This igneous method of concentration could be and has been applied by us, in certain cases, to obtain very high concentrates of metallic oxides, other than titanic oxide, when associated with an oxide of iron.

REDUCTION BY ALUMINIUM.

In the reduction of metallic oxides by the carbon method the amount of the reducing agent, the carbon, is of little consequence from the point of view of cost, but when the metallic oxides are reduced by aluminium any oxide of iron associated with the oxides of the other metal or metals to be reduced in the ferro requires a certain amount of the much more expensive reducing agent, the aluminium.

In this method the aluminium can be used in two different physical states, in powder or very finely com-

* From the Iron Age.

minuted—that is, Dr. Goldschmidt's method—or as a bath, which is the method we have introduced.

Aluminium in powder has been known for the last fifty years or so as a powerful reducer of metallic oxides. The powdered aluminium was mixed intimately with the powdered oxide to be reduced and the mixture heated in a crucible, but these experiments were mere scientific or laboratory curiosities, the reaction being immediate, and, under these conditions, violent to the extent of projecting the incandescent mass out of the crucible, proving actually dangerous if operating on more than insignificant quantities of materials. It was due to Dr. Goldschmidt to make an industrial application of this experiment. Instead of heating directly the mixture charged in a proper vessel, he does it indirectly by using a primer made of a mixture of powdered aluminium and an oxide which yields its oxygen easily, placing this primer in the mass to be reduced, and starting it by means of a ribbon of magnesium or in any other appropriate manner. In this way the reaction, though requiring but a very few minutes (two or three), proceeds by contiguity of contact, and without the intervention of any external heat, the oxidation of aluminium to alumina at the expense of the oxygen proceeding exothermally, once started at one point of the mass.

Without entering into a discussion of the value of the method as applied to the manufacture of ferro metals, we may be allowed to say that, owing to the very rapidity of the reaction, when operating on large masses there is some danger, unless a perfect and absolutely intimate mixture of the powders of aluminium and oxides, difficult to realize, be secured, that some parts of the mass may escape reduction, and that aluminium may be found in the ferro to an objectionable extent. This has been the case at least in two ferros obtained by this method, and imported from Europe. They contained, respectively, 6 and 10 per cent of aluminium, according to analyses made by reputable chemists. The operation can be made, to a certain extent, continuous, by using a certain amount of primer to keep the mass of metal in a molten state, but obviously a large daily production involves at least delicate manipulations and special experience and care.

At any rate, admitting the best possible and most favorable conditions and results, the price of aluminium in powder becomes a factor of great importance.

Aluminium in powder in Europe costs about 1.75 times the price of aluminium in ingots, and here in the United States more than double, 70 cents, as against 30 cents, and that by the ton. For this reason alone the use of aluminium in ingot, instead of in powder, must necessarily reduce considerably the expense of manufacture, as the aluminium enters in the final cost for at least one-half to three-quarters of the latter. The method that we have introduced, and by which tons of ferros can be made, is also simpler of application and manipulation and necessarily cheaper on this account also.

The operation was carried on in an electric furnace like the one described above. The sides of the central cavity were preferably lined with magnesia bricks or other refractory materials, which have the double advantage of being bad conductors of heat and of preventing the contamination of the alloy by contact with the carbon of the hearth (on the sides at least). The furnace was charged with aluminium (scrap, ingots or the like), in proper proportion to secure the complete reduction of the metallic oxides (chromic, tungstic and vanadic, molybdic, titanic oxides, etc., associated with more or less oxides of iron). The aluminium melted immediately. Into this bath we shoveled the concentrates (or the oxides themselves, if rich enough in that condition), coarsely granulated, or in moderately fine grains. The reaction sets in immediately, the oxides of iron reduced first forming a bath of iron in which the other metal, reduced from its oxide by the molten aluminium, dissolves. The furnace becomes incandescent, and the current has generally to be moderated, or even stopped for a short time, until the reaction is complete, when it is turned on again in order to keep the ferro obtained in a molten state. After tapping a fresh quantity of materials is charged and the new operation proceeds as before. The labor is reduced to a minimum.

With two men at the furnace we have made in this manner 650 pounds of ferro-tungsten, of 76 per cent tungsten, with about 11 horse-power, in 30 minutes, counting time of charging and casting. The ferro contained: Aluminium, none; carbon, 0.66 to 0.90 per cent. We have made in the same manner ferro-chrome of 70 per cent chromium; ferro-titanium, containing from 10 to 75 per cent titanium, and from 0.25 to 0.75 carbon, with no or but a very small quantity of aluminium.

However, while the ferro is kept melted by the current a fresh addition of a small quantity of oxide of iron or of the concentrates or ores themselves (if rich enough) would remove all objectionable quantities of aluminium if necessary or required.

If we use rutile or its equivalent, our "titanic concentrate," or "artificial rutile," when working for ferro-titanium, for instance, we may add good scrap iron after the aluminium is charged. This forms a bath with the aluminium into which the rutile or the other oxide to be reduced is charged. Thereby we save on the current required for the reduction of the oxide of iron, for which is thus substituted an equivalent quantity of iron, which has only to be melted, although this is not an item of as much importance as the saving of the amount of aluminium otherwise found necessary. This bath of iron is proportioned to the percentage of the other metal aimed at in the ferro. It can easily be understood that by charging into the bath of aluminium a mixture of two or more metallic oxides, containing oxide of iron, a multiple ferro may be obtained, such as chrome-titanium-ferro, tungsten-titanium-ferro, chrome-tungsten-ferro, or the like.

To illustrate the saving on the cost realized by using this bath of aluminium instead of the powder, let us take the actual quotation (by the ton) in New York of the aluminium in ingots of such a quality as we have used in our operations (it is 30 cents per pound), and of the aluminium in powder, which has been quoted to us at 70 cents a pound by the ton and $1 by the pound. In order to reduce 100 pounds of the Canadian chromite concentrates treated (chromite, containing 65.16 per cent of chrome oxide and 27.36 of iron oxide, and capable of giving theoretically 56 pounds of ferro-chrome of about 70 per cent chromium) 32 pounds of aluminium are required. Assuming that incidental expenses, cost of ores, labor, etc., are the same in both cases, there is, for aluminium alone, a difference of about 22 to 23 cents per pound of alloy produced. Whatever allowances may be made for losses in both cases, whatever may be the relative price of the two kinds of aluminium, there will result necessarily proportional saving, and we may even add that the manipulations, when dealing with a bath of aluminium, require obviously less labor.

(To be continued.)

A NEW ULTRA-VIOLET MERCURY LAMP.

By DR. O. SCHOTT.

IN addition to the visible radiation, all light contains also dark rays, not perceptible to the eye. These are known either as ultra-red or heat rays if their wave length is greater than that of visible light, or as ultra-violet, actinic, or chemical rays, when of shorter wave length than the visible spectrum. Within the last ten or twenty years, the development of physics and medicine has disclosed certain properties of this form of radiant energy, which are not only highly interesting from the point of view of pure science, but seem calculated to be of great service to mankind. In consequence, the demand has arisen for a practical and comparatively cheap form of apparatus for producing these ultra-violet rays, or as we may term them briefly, "uviol" rays.

The want has been supplied by a modification of the Hewitt mercury vapor lamp, the walls of which are made of a special glass prepared in the works of Dr. E. Yschimmer in Jena.

The new lamp consists of a tube of suitable shape—usually straight—made of special glass transparent to uviol rays, 8 to 30 millimeters in diameter and 20 to 130 centimeters long. Platinum terminals are fused in through the glass at the two ends, and are tipped with carbon knobs, so that each pole may be used either as a positive or as a negative pole. The lamp contains 50 to 150 grammes of mercury, according to its size. This mercury not only furnishes the vapor necessary for the working of the lamp, but also serves for starting the luminous discharge and for cooling the negative pole. The dimensions are so calculated that the lamp can be connected up to leads of the usual tension of 220 or 110 volts without undue loss of current.

To light the lamp, it is not enough simply to connect it to the leads; the two poles must be for an instant joined by means of the mercury in the lamp, which for this purpose is tilted so as to allow the metal to flow from the one to the other. When once the discharge is started, it will continue after the mercury has fallen back to its normal position. The lamp being made with carbon poles, the ignition may be effected from the positive to the negative end, or *vice versa*, without injury to the lamp (through disintegration or fusion of the platinum terminals); the negative pole may even be laid bare for several seconds without harm while the lamp is being lighted. When, however, it is to run for a prolonged period, it is imperative that the negative pole be immersed in mercury.

I have experienced considerable difficulty in maintaining a sufficiently high vacuum in the lamp at high electric tensions. Any defect in this matter will very soon cause the lamp to go out.

In order to obtain a maximum transformation of current into radiant energy with a difference of potential of 130 to 190 volts at the terminals (220 at the leads), the tube must be at least 130 centimeters long. Such a long tube is awkward to handle, especially in the operation of igniting the lamp. It may be shortened to one-half by giving it a U shape. This also broadens the field illuminated. The same form, on a smaller scale, is also very practical when internal cavities of the human body are to be exposed to uviol radiation. Two or three lamps of 50 to 60 centimeters length each may be connected in series, and arranged one above or behind the other as required.

The spectrum of the uviol lamp consists of a very large number of lines ranging in wave length down to 253 micromillimeters. From 405 downward these represent uviol rays, and this portion comprises about four-fifths of the whole compass of ultra-violet light which is transmitted for any considerable distance through air.

The light of the lamp displays all the properties characteristic of ultra-violet waves. Ozone can be detected by its odor. A negatively-charged electroscope is rapidly discharged by these rays. Great care must be taken to avoid continued exposure of the eyes to the light of the lamp, as it will cause inflammation.

It is difficult to form any idea as to the manner in which the light is produced in the tube. There seems to be some reason for supposing that the ultimate particles of mercury in the evacuated tube are hurled with great velocity by the electric current from the negative to the positive pole, thus acquiring a very high temperature, and emitting intense light. The rays of short wave length so produced render the mercury vapor conducting, thus establishing a path for the continuous electric discharge through the tube.

From some determinations which have been made of the luminosity of the uviol lamp, it appears that in a favorable case it consumes 0.64 watt per Hefner unit. In estimating its efficiency, it must be borne in mind, however, that only about one-half the energy actually radiated by the lamp consists of visible rays, and in point of fact the uviol lamp is an exceedingly efficient device for converting electrical energy into radiant energy of short wave length.

Among the branches of science in which a source of radiant energy of short wave length is likely to prove valuable, the first that naturally occurs to us is photography. Trial experiments have shown that the uviol lamp is very well adapted both for taking photographs and for copying them by artificial light. The comparatively expanded character of the lamp, especially when two are used in conjunction, the one vertical, the other horizontal, gives rise to strong, soft shadows. In order to avoid the inconvenience of having to wear protecting spectacles in such photographic work, lamps intended for this purpose are best made of glass which absorbs the rays of extremely short wave length, as it is to these that the injurious action upon the eyes is due.

Chemistry also may be expected to apply these rays of high frequency to initiate certain processes, for instance, to cause the combination of two bodies, as in the case of chlorine and hydrogen. We have tested several reactions which are mentioned in the literature and which take place under the influence of light, and we find that uviol will in some cases convert a compound from one modification into another, or will cause polymerization. Such delicate agencies are of great value in chemistry for effecting the rearrangement of the atomic complexes of which the molecules of many labile organic compounds are built up.

At the suggestion of Prof. Von Gerichten, and using material supplied by some of the larger German color works, experiments have been conducted here, to test certain dyestuffs by the aid of the uviol lamp, with regard to their fastness to light. The bleaching action of the sun is due to slow chemical processes, induced by ultra-violet rays present in sunlight. The unfavorable climatic conditions of our latitudes have compelled these color works to establish their test stations in southern localities, as no artificial light, not even that of the electric arc, has the same effect as sunlight. From the favorable results of a large number of experiments made in this direction with the uviol lamp, it seems probable that in future the test of colors for fastness to light may be performed in as many days as there were hitherto required months.

The uviol lamp has a remarkably deadly effect upon small insects. A common fly dies within one minute when brought to a distance of about 1½ centimeters of the lamp—a distance at which the heat cannot be sufficient to be harmful. Under a lamp which was suspended near an open window at night, in summer, thousands of small dead insects could be swept up in the morning. On smaller organisms also, on bacteria, the uviol lamp exerts a fatal action. Prof. Gärtner, of Jena University, is at present engaged upon extensive researches on this point.

The most important and also the most interesting application of ultra-violet light is the use to which it has of recent years been put in medicine for the treatment of skin diseases. It was Finssen who, some nine years ago, did the pioneer work, and created a sensation with his lupus cures. For his source of ultra-violet light he used the ordinary carbon arc lamp, fitted with water cooler and projecting piece. Although such a lamp sends out comparatively little radiation of short wave length, it was found possible to increase the proportion of the latter by increasing the dimensions and using large currents. From the nature of this arrangement it is plain that only a small patch can be treated at a time, and that hence frequent sittings are necessary for dealing with diseased areas of considerable dimensions. Besides, the large quantum of heat and light unavoidably emitted along with the ultra-violet rays is not only an irksome factor in this procedure, but also renders it rather costly.

The case is very different with the uviol lamp. Owing to its expanded form, it furnishes a means for exposing large surfaces, ranging in area to 1,400 square centimeters, to intense radiation, and, owing to the small amount of heat emitted, it may be approached to within less than a centimeter.

If the normal, healthy skin is exposed for 5 to 15 minutes to the action of the uviol lamp at a distance of 1 to 3 centimeters, there is at first no visible change. It is only some hours after the exposure that a reddening appears, which continues to increase for about a day, at the end of which period it reaches a maximum. At this stage a slight burning sensation is felt, a few days later the patch of skin begins to itch and peels off, and the redness ultimately disappears in the course of two or three weeks.

Profs. Stintzing and Matthes, in Jena, are at present conducting some experiments to determine the value of the uviol lamp in the treatment of skin diseases. Although it is only a short time since these experiments were started, some cures have already been effected in the case of some mild forms of eczema, some of which were of several years' standing. Some

more serious cases have required a daily treatment of one-quarter to one-half hour to bring them to the threshold of a cure. A case of erysipelas was cured almost without any fever setting in. It is impossible to judge of the effect upon lupus in the short time which has as yet elapsed.

Most skin diseases showed a favorable influence by the radiation, provided sufficient time was given.

When properly handled, the uviol lamp may be used for 1,000 hours without appreciably deteriorating. For the use of inexperienced operators, a special stand, devised for the purpose, is to be recommended. By its use errors of manipulation, leading to the premature extinction of the lamp, can be readily avoided. This stand comprises the requisite resistances, a coil of wire, plug keys, amperemeters, etc., and appliances preventing the negative pole from remaining too long uncovered by mercury. The stand also enables the operator to set the lamp in all positions necessary for treating the human body. For exposing the head to the rays, a head rest is required, which can also be used for supporting the hand or arm.—Abridged translation of an article in the Zeitschrift für Angewandte Chemie, 1905, p. 615.

SUPERHEATING LOCOMOTIVES.*

THE demands made upon locomotives in point of speed and tractive power have steadily increased, and will continue to increase, but there are various objections to improving efficiency by increasing the size of locomotives.

Their weight is limited (in Prussia) by the regulation that no wheel shall exert upon the track a pressure exceeding eight tons, while constructive considerations limit the number and determine the arrangement of wheels. The maximum length, width, and height are prescribed by agreements conditioned by the dimensions of existing roads, tunnels, bridges, and turntables. The diameter of the boiler is restricted indirectly by the same requirements, and its length is limited by the extent of grate that can be served by the stoker and by the economical utilization of furnace gases.

The efforts of locomotive builders, therefore, have long been directed to increasing the efficiency of the steam, and thus obtaining greater power from a given boiler capacity.

In this sense the introduction of compound engines marked an important advance, but compound locomotives with two cylinders experience difficulty in starting and are unsymmetrical, as the right and left engines differ in size and weight, while the use of three or four cylinders involves much waste of energy in friction.

All these locomotives are driven by saturated or wet steam, which enters the cylinders directly from the boiler. Hence some water condenses in the cylinder and some is carried over mechanically in fine drops, especially at high speeds, both of which quantities of water have been heated uselessly.

Hence, also, both boiler and tender must carry water which is eventually wasted.

If, however, the steam is superheated before it is admitted to the cylinder, there is no condensation in the latter, the water that is carried mechanically into the superheating tubes is there vaporized, and, independently of these economies, less water need be evaporated to fill the cylinder, owing to the expansion caused by superheating—or, conversely, larger cylinders may be used, and greater tractive effect obtained with a given boiler. The total saving in coal amounts to 25 per cent.

Although these advantages of superheated steam have long been known, no practical test of its efficiency in locomotives was made until six years ago, and only very recently have superheating locomotives been built in considerable numbers, as mineral unguents and improved stuffing boxes are needed to withstand the high temperature (about 300 deg. C. or 572 deg. F.) and pressure.

In the "boiler superheater," Fig. 1, the steam flows down from the dome through a short pipe to a superheating chamber traversed by the boiler tubes, rises thence as superheated steam to the gage chamber in the dome, and finally passes through the pipe, *R*, to the cylinders.

In the "smoke superheater," Figs. 2 and 3, the wet steam flows from the dome through the pipe, *R*, to a chamber on the right of the smoke-box, thence through thirty small tubes to a second chamber on the left, thence back through larger tubes to a third chamber on the right, and thence, as superheated steam, to the cylinders.

The superheating tubes are inclosed in a separate compartment of the smoke-box fed by the large pipe, *H*, directly from the firebox. The superheating apparatus is controlled by valves, by which it can be thrown into full or partial action or cut out entirely.

In the newer construction of W. Schmidt, Fig. 4, the smoke superheater is inside the boiler, and consists of a series of smoke tubes inclosing steam tubes and lying above the boiler tubes. This type possesses the advantage of placing the superheater over the driving wheels, where it contributes to the effective weight of the locomotive.

The first superheating locomotive was built by the Vulcan Works, of Stettin, in 1898, the second by Henschel & Son, of Cassel, in the same year. Both had "boiler superheaters," which proved unsatisfactory and led to the construction of a locomotive with a smoke superheater similar to Fig. 4. Another, built by Borsig, of Berlin, attracted great attention at the Paris Exposition in 1900. Other types were developed, and proved so successful that numerous superheating locomotives were built. Early in 1904 twelve fast passenger and twelve freight locomotives were delivered to the railway directors in Breslau, Elberfeld, Cologne, and Frankfort.

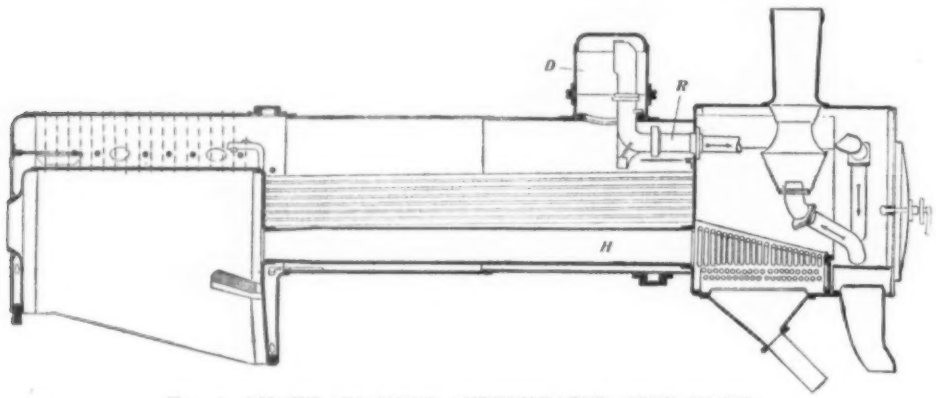


FIG. 2.—SMOKE CHAMBER SUPERHEATER (SIDE VIEW).

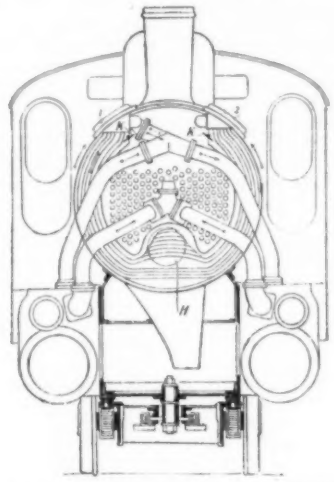


FIG. 3.—SMOKE CHAMBER SUPERHEATER (FRONT VIEW).

In addition to their good showing in ordinary service, superheating locomotives have won two special triumphs. In the experiments made last year to determine the type of locomotive best adapted for service on the Berlin Stadt- und Ringbahn, the superheating locomotive built by the Union Works in Königsberg, Fig. 5, alone proved able to move the heavy trains at the required speed of 60 kilometers (37 miles) an hour—an increase from the former average speed of 45 kilometers (28 miles).

Again, in the trials made between Marienfelde and Zossen this year, a superheating locomotive built by Borsig for ordinary express service achieved most brilliant results. Several such engines are in actual service (Figs. 2, 3, and 6).

In the speed tests the locomotive drew six cars at 128 kilometers (79.4 miles) and three cars at 135 kilometers (83.7 miles) per hour. Although a (non-superheating) locomotive which was sheathed to diminish air resistance made 137 kilometers (84.9 miles) the superheater possessed the great advantage of costing $7,500 less than its colossal competitor and weighing only 90 tons in contrast to the latter's 145.

The other locomotive was 27 meters (89 feet) long without its tender, from which it had to be uncoupled to use a turntable. The maximum indicated horsepower of the superheater was 1,800, with a boiler surface of 100 square meters (1,076 square feet) and a superheating surface of 30.75 square meters (330.99 square feet).

In the introduction of superheaters the Prussian railway authorities have taken a progressive step which the other (German) railways may be expected to follow, sooner or later. Though the famous American lo-

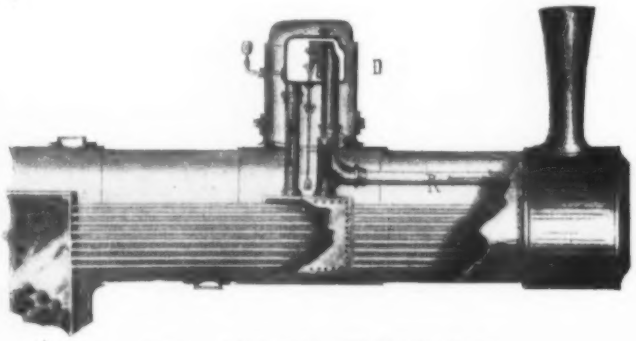


FIG. 1.—PIELOCK SUPERHEATER.

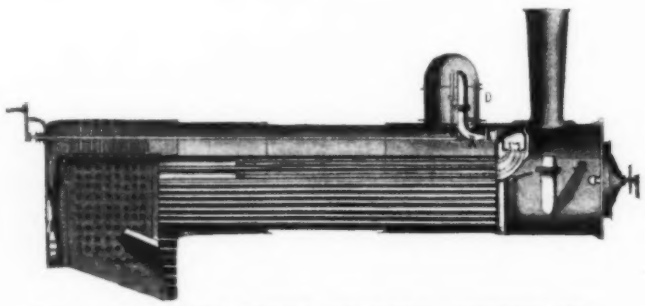


FIG. 4.—SCHMIDT'S SMOKE CHAMBER SUPERHEATER.

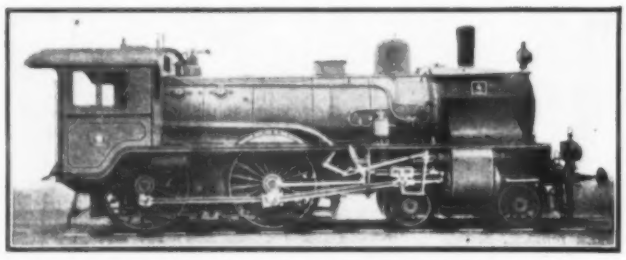


FIG. 6.—BORSIG SUPERHEATED STEAM PASSENGER ENGINE.

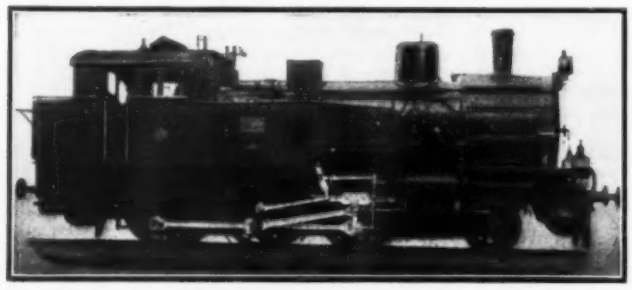


FIG. 5.—SUPERHEATED STEAM LOCOMOTIVE OF THE UNION WORKS.

* Rudolf Voedt in Die Umschau.

comotives are imposing in size, the comparatively small German superheaters, rather than the American giants, represent true technical progress.

OSCILLATIONS OF RAILWAY VEHICLES.

AN investigation of the oscillations of railway vehicles is of interest, both on account of the derailments any excessive oscillations may give rise to, and because of the disagreeable effects of such shocks on railway passengers, the rolling stock, and the track. In view of the increasing speeds of rapid trains, this question should receive more and more attention. Now, such oscillations are due either to a defective state of the stock or to defects in the track.

Many engineers have dealt with the problem at issue, and have first examined such oscillations as are due to the stock, while those produced by the track itself have been studied more particularly of late years. The most important factors in this connection are the periodical vertical level differences at each rail joint. As the joints of the two rail lines are mostly situated in front of each other, their respective effects are exerted on the two wheels of the same axle at the same time, so as to give rise to simultaneous vertical oscillations, unless horizontal oscillations complicate the phenomena. The opinion has been enunciated that these vertical oscillations would prove particularly dangerous if there exist synchronism between the time employed by a vehicle in traversing the length of the rail and the duration of its natural oscillations on its springs, and this special speed is what has been called "critical speed."

Now, G. Marié, in a note recently read before the French Academy of Sciences, states that railway vehicles cannot possibly be prevented from running sometimes at their critical speed, this corresponding frequently with the most usual speeds. Such divergent oscillations as should result according to theory, however, are not generally produced, owing to the friction of the spring plates, prongs, and guides, which factors had not been taken into account. As, however, such oscillations are liable to occur in certain cases, when they may be productive of real danger, they obviously deserve special attention. M. Marié has investigated them by means of graphical processes in a simple theoretical case, and has established the following formula giving the condition of convergence:

$$h < 2fa$$

where h is the maximum periodical level difference of the track (about 0.004 millimeter), f the relative friction of the spring, viz., the constant ratio between the sum of the friction of the spring plates, guides, etc., to the corresponding value of the power of the spring, and a the pitch of the spring under immovable loads (0.03 millimeter to 0.25 millimeter as the case may be).

This formula can be applied to almost any practical case met with in railway operation, and the following conditions are inferred from it:

In order to reduce the value of h, a track as rigid as possible should be employed; springs of great flexibility and at the same time a fairly high relative friction should be utilized.

If the above conditions be complied with, the vehicle will not show any vertical divergent oscillations, quite independently of the speed. Applying the formula to a certain number of railway vehicles, such as locomotives, tenders, coaches, and vans, the author states that the condition of convergence is complied with in the majority of cases, while certain defective vehicles are liable to give rise to divergent oscillations. He further indicates some graphical processes whereby these conditions can be readily ascertained. There are, however, as pointed out by M. Marié, some other oscillations which may also reduce the practical speed limit.

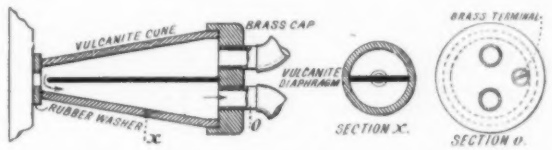
Now, since the above formula was established, practice has shown its correctness first in automobile construction, where the practical advantage of springs provided with additional friction has been evidenced. On the other hand, the electric high-speed traction experiments made in Germany have shown well-constructed railway vehicles to be free from any divergent oscillations due to the vertical level differences in the track, even at enormous speeds.

AN ELECTROLYTIC PROCESS OF PIERCING AND CUTTING PLATES OF METAL.*

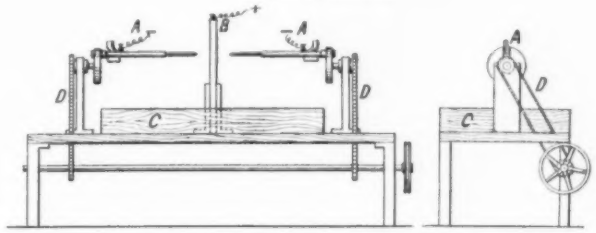
By Our BELGIAN CORRESPONDENT.

MR. COWPER-COLES has recently made a series of experiments upon the electrolytic piercing of metals, and these experiments have given very favorable results. The method is sufficiently rapid to permit it to be applied industrially, and has the advantage of not requiring the softening of the metals, as in other processes.

The latest form of the apparatus devised by the inventor comprises a hollow truncated cone of vulcanite, the narrow end of which is provided with a rubber ring designed to be applied to the piece to be pierced, and the wide end with a plate of copper containing two apertures for the entrance and exit of the electrolyte. This circulates above and beneath a central insulating partition that permits of its passage downwardly only near the nozzle. The piece to be pierced forms the anode. The current traverses the liquid and ends at a longitudinal rod fixed at the other end of the partition to the wide base of the cone. This rod forms the cathode. The iron deposits thereon and is gradually carried along by the quite rapid current of the electrolyte.



SECTIONS OF VULCANITE CORE CONTAINING ELECTRODE.

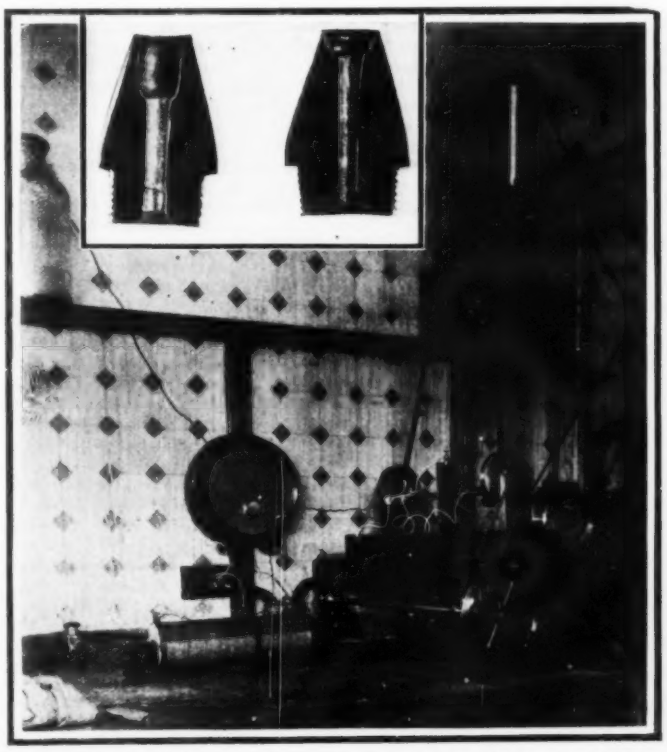


SIDE AND END ELEVATION OF THE APPARATUS WITH MOVABLE ELECTRODES FOR PIERCING LARGE HOLES.

The rubber ring determines the form and size of the aperture to be pierced in the metal. Salt water and dilute sulphuric acid give the best results for the piercing of iron.

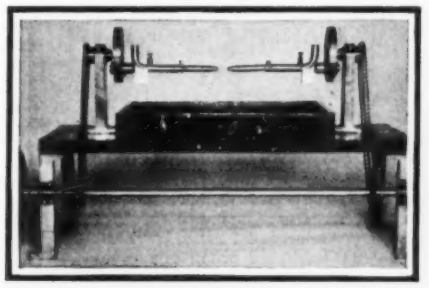
Large-sized holes can be bored by cutting out their contours by a special electrolyzing apparatus. This comprises two cones, *A A* (see diagram), placed on each side of the plate, *B*, which it is desired to pierce. The cones are mounted on disks, upon which they can be radially adjusted, and these disks are revolved by means of sprockets and chains, *D D*. The jet of electrolyte thus describes a circle of the diameter which it is desired the hole shall have. The electrolyte enters the cones by gravity simply, and falls into a receptacle, whence it is pumped and forced into a reservoir above.

Mr. Coles's method might evidently prove of great utility in marine work for cutting plates, bolts, and chains situated beneath the load water line, since the sea water might be utilized as an electrolyte.

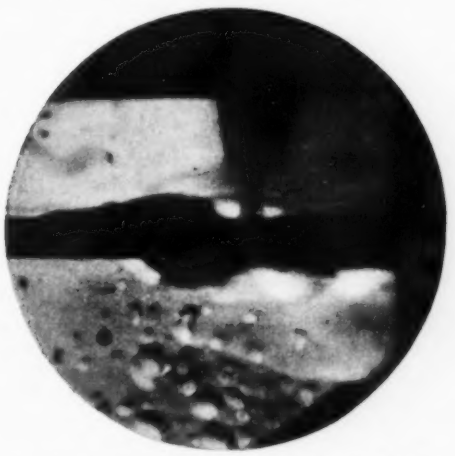


THE COWPER-COLES ELECTROLYTIC BORING APPARATUS.

The tank containing the electrolyte is seen above at the right. The liquid descends by gravity through two pipes to the two cone tipped tubes mounted on revolving disks and pressing against the metal plate to be bored, which is mounted between them. The electrolytic action between the plate (to which the + wire is attached) and the cones (which form the — poles) quickly pierces a hole through the metal. In the upper part of the picture are shown two tips with holes pierced by electrolytic means.



COWPER-COLES ELECTROLYTIC APPARATUS FOR PIERCING LARGE HOLES.



HOLE PIERCED THROUGH METAL BY ELECTROLYTIC MEANS.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

A GIGANTIC EMERALD.

RECENTLY there was disposed of at auction in Berlin an immense emerald, which at one time belonged to Alexander von Humboldt. Emperor Nicholas I. of Russia presented this huge stone to Humboldt. It measures 10 centimeters in length and 6 centimeters in width. It is polished on four sides, while the other parts are left in their original crude state. The setting of the stone is very original. It rests upon a rock of massive silver, about which six gnomes are grouped, pickax in hand, and apparently vigorously working to

dislodge the gem from its precious matrix. The base is composed of ebony decorated with silver. This work of art was brought again upon the market by the recent razing of the Villa Neuman in the Potsdam street. For the astonishingly low price of 2,020 marks (about $505) it passed into the possession of its new owner.

HIGH-SPEED, LONG-DISTANCE ELECTRIC TRACTION.*

By CHARLES A. MUDGE.

IT is a fact well recognized, at all events among engineers, that the time occupied in being transported from one city to another is greater than it should be, and that the average speed of modern travel is relatively low, and has not advanced in the same ratio as have many other important civilizing agencies.

If our offices had been on the tenth floor of the Commercial Cable Building thirty years ago, it would have taken us four minutes to reach them from the ground floor, but to-day it takes us only a quarter of a minute, a saving of over 90 per cent of time.

I remember hearing my father tell the story of how it used to take him 48 hours to go 100 miles by canal boat sixty years ago. After thirty years he got over the same ground in three and three-quarter hours by rail, or a saving of 90 per cent of time.

If the same relative progress had been made in the last thirty years in transportation, we should have been traveling at the rate of over 200 miles an hour to-day; but, as a matter of fact, the schedule time over this same road is only 20 per cent faster than it was thirty years ago.

In other words, it seems that in the last thirty years conditions have improved over 90 per cent when traveling away from the surface of the earth, and only 20 per cent when traveling along the surface; or that there has been over 90 per cent increase in efficiency in the former case, with 2,000 pounds per ton resistance to fight against, and only a 20 per cent increase in the later case, with approximately 20 pounds per ton resistance.

Possibly some of these astounding facts were revolving in the brains of two of the greatest industrial chiefs in Europe, Messrs. Rathenau and Schweiger, while they were making a trip from Berlin to Milan, six years ago, at a schedule speed of 30 miles an hour. The results of their being thus accidentally thrown together on this occasion were the tests made between Marienfelde and Zossen in the years 1901, 1902, 1903.

As is generally known, these tests were made under the direction of a company organized for the special purpose, and known as the "Studiengesellschaft für Elektrische Schnellbahnen."

The objects of the tests were to make a study of many of the heretofore incompletely known, and in some cases wholly unknown, factors entering into electric traction at speeds never before attempted, such as collecting current at high voltages, traction and air resistances, best design of trolleys, motors, transformers, brake gears, and trucks, the power required to run at high speeds, the details entering into the construction of the permanent way, and the collection of other data, in order to calculate costs of future installations.

The track selected for the experiments parallels the main line running south from Berlin toward Dresden, and is used by the Ministry of War for giving instruction to the railway corps of the army. The car barn was located 5 miles from Berlin, at Marienfelde, where the tests were started toward Zossen, 14½ miles distant, over a track having only two decided curves, of 1¼ miles in radius each. The first one occurred 3⅛ miles from the car barn, the second 7 miles further on, leaving 4⅜ miles to Zossen. This practically divided the line into three parts—4 miles at each end for acceleration, and 7 miles for running in the middle—with almost no grades; conditions about ideal for the tests contemplated.

Power was supplied from a central station seven miles distant to a cable house along the line a little over one-half mile from the car barn, where it was connected directly to the trolley wires through automatic circuit interrupting devices.

The apparatus installed in the Allgemeine car differed quite materially from that installed in the Siemens & Halske car, and my remarks will refer only to the apparatus used in the Allgemeine car.

The car body was 69 feet long and 9¼ feet wide, and was divided into three compartments by a so-called machine room, 12 feet long in the middle, which contained the starting rheostat and high-potential switches, and was not allowed to be occupied while current was on. The other two compartments were utilized for measuring instruments and for passengers, and were connected by a narrow passage through the machine room.

On either side of the machine room underneath the car floor the transformers were fastened. The six-wheel trucks were spaced 43 feet 7⅝ inches from centers, and the 49 3-16-inch wheels had a base of 6 feet 3 inches, which was increased later to 8 feet 2½ inches.

Three-phase current was used, and the highest recorded voltage in the car during any test was 14,150. The current collectors were of the sliding bow form, six in number, and placed in groups of three on each end of the car, two bows working in parallel on each plane.

The weight of the complete car with fifty passengers was 100 tons (2,000 pounds to the ton), which was increased four tons in the last year of the tests by alterations necessary to accommodate the new trucks and by balancing weights.

Passing over hurriedly the results of each year's tests, in order to give a general idea of the manner in which they were conducted, and before taking up in detail the actual construction and installation of the apparatus—which will be the main theme of my remarks—we may summarize as follows:

The first year, September, October, and November, 1901, was what might be termed a "try-out" period. The entire installation, with the exception of the permanent way, being new, it was necessarily handled with greater caution than it would have been if the apparatus had been of a more standardized construction. Before the car was taken from the works all apparatus was thoroughly tested, and for this purpose a stationary bedplate, having four run wheels, was arranged under each truck, the wheels on the bedplate having profiles similar to rails, and made wide enough for brake straps of dynamometers.

In this manner the motors were run up to speeds corresponding to 200 kilometers, and the power required was measured with the dynamometers.

Very elaborate tests were also made on bearing frictions at high speeds, and interesting data were collected on the properties of different lubricants under severe conditions of pressure and speed in connection with different metals and alloys.

From the results of these tests the rolling friction was estimated to be about 10 pounds per ton at 125 miles per hour, which was somewhat in excess of the values found during the actual operation of the car.

Numerous other preliminary experiments were made, to determine the air resistance, the proper form of the car end, the best design of current collector, and an efficient brake rigging.

After all apparatus had been given as thorough a shop test as possible, the car was hauled approximately 500 miles by a steam locomotive, in order to loosen it up. After this many different runs were made, the maximum speed attained during this year's tests being 100 miles per hour.

During the progress of these preliminary runs, it was shown conclusively that no trouble would be experienced, as had been anticipated, from collecting currents large enough to run the car at 125 miles per hour, with voltages up to 14,000, provided the car could be made to run smoothly enough. Some trouble was experienced in keeping the sliding bows on the trolley wires, but this was mainly due to the vibration of either the car or the trolley wires, rather than to any fault in the design of the trolleys themselves.

It was noted very early in these tests that the permanent way was not at all suitable for running cars of this weight at such speeds. It was decided to replace the 67-pound rails with heavier ones of 82½ pounds per yard, and to increase the size and number of ties per rail over the middle portion of the road, which also was to be furnished with guard rails for ten miles of its length.

Above 90 miles per hour the car began to sway from side to side very decidedly, and it was considered unsafe to run above a maximum speed of 100 miles per hour. This made it necessary to alter the design of the truck, and to allow a portion of the weight of the car, which was carried entirely at the truck center, to be borne by the truck frame. It also suggested the idea of flexibly supporting the center-pin bearing in the truck. Both features were admirably carried out in the design of the truck used during the last year of the experiments, which will be described in detail later.

The electrical data obtained during this first year's tests were duplicated in the third year's tests, which were carried out in a more elaborate manner. Therefore no summary of results will be attempted now. The braking facilities were not at all sufficient, although two shoes were applied to each of the twelve wheels. This was due mainly to the arrangement of levers and to the fact that only two brake cylinders per truck were used, which was changed later to four cylinders per truck, and to a much simpler lever system.

The second year of the tests, September, October, and November, 1902, was occupied mainly in determining the train resistance at different speeds, in measuring the power required for different loads and speeds, in determining the losses to the transmission line, in collecting the necessary braking data for computing the coefficients of friction for different speeds, and in determining the alterations necessary to be made in the car and the permanent way, to allow us to run up to 125 miles per hour.

These tests were conducted up to a speed of only 75 miles per hour, as the observations of the previous year showed that the permanent way would not stand much higher speeds. To determine the train resistance as well as the energy absorbed in running the car, a distance of four miles, starting at the car barn, was very carefully measured, and all curves, grades, and levels were absolutely fixed. This made it possible to correct the observed data so accurately that the recorded results in this year's report are of the greatest value.

The brake tests made in this year were not as satisfactory as those in the following year, on account of the complicated brake rigging used, which did not allow of easy adjustment, and which I will not therefore attempt to analyze.

Suffice to say that the maximum retardation of two miles per hour per second was recorded at 70 miles per hour with a total brake pressure equal to 155 per cent of the weight of the car. At the conclusion of the tests this year it was found necessary to build new trucks with a 2-foot longer wheel base, and to support the car body on the truck frame at some distance from the center pin; also to flexibly support the center pin in the truck, thereby allowing the car body to have a movement of about one inch on each side of the truck center independent of it, and in a line at right angles to the track. In order to observe the action of the springs and their connecting levers, it was decided to place them on the outside of the frame of the truck. The tests this year were of value in showing what alterations in the car and permanent way were necessary in order to be able to run at higher speeds.

The tests of the third year, which were the most elaborate and formed a reliable check of the previous tests, have given us a substantial basis upon which high-speed work may be attempted.

The results noted in the behavior of a type of apparatus never before used, and operating under actual conditions of service, combined with the experience gained in the construction of the permanent way, give us a basis upon which the solution of the problems of high-speed transportation may be established, and make the whole question considerably less formidable than it once seemed.

In the first place, they showed us that it was practically possible, from an engineering point, to move from place to place at least twice as fast as we are at present accustomed to.

Data of very great value were secured on the much-discussed question of air resistance, and although the formula may not be straightened out to suit everybody, we know positively if we run our car, for instance, 50 miles per hour, we can expect a maximum air pressure of about seven pounds per square foot at the front of it; and if we double the speed we will get four times this pressure, and if we triple the speed we will run into trouble and get nine times this pressure. If we shape the nose of our car properly, we will be able to reduce these figures 10 per cent. Also, if we run our 100-ton car 50 miles per hour on a level track without paying much attention how the front of it is shaped, it will take about 150 horse-power. When we double the speed, it will take six times this amount of power; but if we attempt to triple the speed, i. e., to run at 150 miles per hour, we would have to supply about eighteen times the amount of power it takes to run at 50 miles per hour.

These facts are not so serious as they seem, when we consider that the amount of power necessary to drive a car or train at 100 miles per hour, with which we would be content at present, can easily be applied to the axles without any alteration in the standard gage, and in fact, with very little, if any, change in the standard truck constructions.

As had been anticipated, the new truck used this year, with its greater wheel base, worked much more satisfactorily than the old one. The feeling that the car body was being carried along by something that knew its business came to all who took part in the tests, and the sense of security when running at high speeds around curves was a comfortable one.

This was due not only to better designed trucks, and the manner in which the car body was supported on them, but also to the excellent service given by the new 82½-pound rails, the closer-spaced ties, and the more substantial ballast. At the very outset of the tests considerable difference was noticed in the behavior of the car when running above or below 100 miles per hour. At about this speed the car seemed to take on a swinging lateral motion, which at times became so pronounced that it endangered the overhead work and created a feeling of insecurity in the passengers.

The cause of this was found to be the unsymmetrical disposition of the motors and transformers on the car. This was ascertained by taking the weight of the car under each wheel, which showed a maximum variation of 1½ tons in some cases.

This was counteracted by placing weights along the floor of the car 41½ feet from its center line at each truck, after which no further vibration was noticed, even up to the highest speeds, and the car ran as smoothly as our Pullmans.

The working of the trolleys was satisfactory after they had been properly adjusted, but it was evident that a more substantial construction would have to be adopted on installations where schedule speeds must be adhered to.

The braking results of this year were most interesting, and showed very distinctly that it is a difficult matter to keep the retardation a constant value with the braking apparatus at present at our disposal. The curve of retardation, instead of being straight, has a most undesirable peak at each end, showing that for ideal conditions it is necessary to increase the brake pressure a few seconds after it has been applied, and then to leave it in charge of an automatic device which decreases it as the speed decreases, and as the coefficient of friction increases.

The enormous brake pressures needed at high speeds to give a comparatively low retardation, show very plainly that our familiar friend, the coefficient of friction, is not going to help us in the same proportion that he is doing at present; but if he doesn't, electrical means will most likely help us out. For instance, it was found to take about ¾ of a mile to stop the car when running 110 miles per hour, the initial brake pressure being 150 per cent of the weight of the car. If we had some means of keeping the retardation constant, we could have stopped the car in ¾ of a mile by using the same pressures. Under the most favorable conditions the car could not have been stopped in less than ½

* Address before the two hundred and fifty-first meeting of the New York Electrical Society, held on May 24, 1905, in this city. Mr. Charles A. Mudge was formerly chief engineer of the Railway Department of the Allgemeine Elektricitäts Gesellschaft, Berlin, which took part in the noted Berlin-Zossen trials.

mile when running at 110 miles per hour, which would require a retardation of 3¼ miles per hour per second, which is about the limit of braking with this type of braking apparatus. The pre-eminent value of the braking system employed lay in the fact that it never failed in its operation during all the tests made, and the feeling of security which its absolute reliability inspired.

When you see the end of the road or a sharp curve coming for you at 125 miles an hour, you begin to feel a little uncomfortable, and reach instinctively for that little polished brass handle whose place in the engineer's cab is assured in all high-speed work, and the knowledge that it can be relied on is most reassuring.

To sum up briefly, the first year's tests served to inspire confidence in the undertaking, and to try out the apparatus; the second year showed conclusively what was necessary to make the future tests a success, as well as furnishing a great deal of unquestionably accurate and important data.

The third year's tests give us a safe foundation upon which we can base our future work in this field, and occupy a unique place in modern engineering, in showing results of the highest speed ever attained by any vehicle on wheels.

We will now pass to some of the details of the apparatus used in the tests, which will be illustrated on the screen.

[A number of slides were here shown.]

These few details of the more important pieces of apparatus, which made the collection of such valuable data possible, are of interest to us as showing not only how these particular results were accomplished, but in giving us an idea upon what lines to base our calculations in similar undertakings. The designs of the individual pieces of apparatus themselves may or may not meet our fancy, but, as an aggregation of parts working together for a single purpose, they did their work admirably.

In looking over their weights and dimensions we are struck with their magnitude and liberal margins, and the idea of "better too strong than too weak" seems to be rigidly adhered to. This was purposely followed in all constructions of the more important pieces of apparatus throughout the car, as it was not intended to use these exact designs for future equipments. They give us, however, a most valuable precedent with the assurance that they will work, which is a valuable asset in estimating on similar projects. Basing our ideas upon some of the observations and experiences gained in these tests, we would make use of the following points in approaching a similar problem:

1. Keep the car body as near the rails as possible.
2. Arrange all heavy pieces of apparatus so that their centers of gravity lie in the center of the car, or symmetrically placed to it, and as near the earth as possible.
3. All apparatus mounted above the car floor should be as light as their design will permit.
4. Make the overhead trolley contact *above* the car, in preference to the side of the car.
5. Support the motors flexibly on the axles of the trucks.
6. Give the front end of the car a wedge shape.
7. Support the car body on the truck frame at some distance from the center bolt, and allow it a flexibility in a line at right angles to the track, independent of the truck.
8. Make the total wheel base of the truck of ample dimensions, and not less than 20 per cent of the length of the car.
9. Build the road as straight as possible, and where more than one track is used, make them further apart than our present practice would suggest.
10. On curves, make the approaches of the elevated side of the track longer than usual.

If it were possible to have the wheels along the sides of our cars and the rails between the floor and roof lines, we should have very comfortable traveling. Any condition approaching this, as by keeping the car body near the rails, would share in the benefits thus derived.

A German engineer of considerable prominence has advocated lowering the floor of the car between the trucks, in order to make it ride steadier, utilizing the space above the trucks for second and third class passengers, or for freight and baggage. Although this might be too radical a change in designs of our standard practice, and would not harmonize as well with conditions here as with those abroad, it would undoubtedly give good results. That all apparatus should be symmetrically mounted in relation to the center line of the car was very evident as we approached the 100 miles per hour figure. Our motors were mounted slightly out of the center line of the truck, and it was found necessary to use 275 pounds per motor to counteract this.

(To be continued.)

A CURIOUS INDUCTION EXPERIMENT.*

By CHARLES E. BENHAM.

THE following curious experiment, simple as it is, will probably be new to most readers. Place on a level table two glass tumblers which have been first freed from any superficial moisture by warming them near a fire. Lay a book on each tumbler, the two books being of similar size. The longer sides of the books should be parallel with each other, and the supporting tumblers should be at such a distance apart that the two books are about one inch apart. Place a third book of the same size on a sheet of glass, which must also have been well warmed at the fire. The third book must be laid so that it rests crosswise over the other two, with the sheet of glass between them, as shown in Fig. 1, in which the dotted line represents the piece of glass, the proportionate size of which is thus indicated. On the top book lay a penny, as indicated in the diagram, to act as a conductor for drawing off the electric sparks which are to be produced by this singular arrangement. Now taking the glass carrier, and holding it near the front edge, move it, with its book, horizontally right and left, so that the upper book is in turn over each of the lower ones, in the alternate positions shown in Fig. 2. Whenever it reaches either of these extreme positions, touch the book underneath it with the finger, taking care not to touch the other book, nor the upper one. When the upper book is in the intermediate position shown in Fig. 1 it must be touched, taking care to avoid the earthing of either of the others. Repeat this cycle of movements twelve or

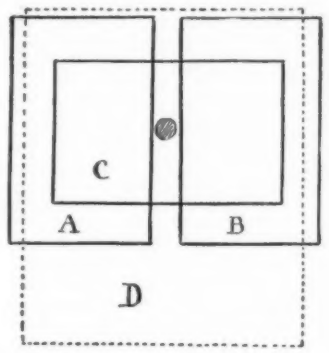


Fig. 1.—A and B the two lower books. C the upper book, resting on the glass plate D, and carrying a small coin, laid on the top of the book.

twenty times, and then, on lifting the glass plate with its book away from the influence of the other two, a little spark may be drawn from the penny on presenting a finger to it. After drawing the spark replace the plate in the intermediate position, Fig. 1, and on earthing the upper book again by touching it as before, its charge will be restored. Continuing the movements, it will be observed that the charge is a growing one, increasing at each cycle, being only limited by leakage from the book corners and by the capacity of the book surfaces. The charge on the upper book may be given up to a Leyden jar each time without loss if the communication from it to the jar is always made previous to its intermediate position, in which, when it is earthed, its loss is made good by induction from the books below. Using large books on the tumblers and, for the upper one, a book of equally extensive surface, though thin for the sake of lightness, quite a strong charge may soon be accumulated in the Leyden jar. If the tumblers and glass sheets are coated with shellac varnish they are less liable to be affected by moisture, and the preliminary warming is unnecessary unless the atmosphere is very damp. The effect is enhanced by using rounded pieces of board instead of the books, and the best effects of all are produced if the conductors are of metal. Three shallow cake tins, about eight inches in diameter, will give very fine sparks, and the snap of the induced charge quickly becomes audible at each successive earthing, the spark of inflowing electricity becoming larger each time until the limit of capacity is reached. The glass will indeed soon become so highly charged that in moving it the cake tin will adhere to it by attraction, while if the lower tins are close together a spark will also frequently fly between them as the upper tin passes from one side to the other. When this happens, however, the process of accumulation is to some extent checked, and the proper distance apart is the shortest distance at which such cross-sparking does not occur.

The experiment is really a modification of one which

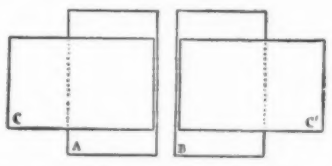


Fig. 2.—A and B the two lower books. C the upper book (the supporting glass plate not shown) in its extreme left position. C the same book in its extreme right position.

has already been described and explained in Knowledge (November, 1904). Each of the lower books receives an infinitesimal charge by induction from the upper one, which, without losing any of its own, is in its central position enabled, when temporarily earthed by touching, to take up an induced charge from the joint influence of both the under ones. Its original charge is thus multiplied at each cycle. Where that original charge comes from is, of course, a mystery. It is infinitesimal, but it is there somehow, and may be either positive or negative—sometimes one, sometimes the other. It appears that all insulated bodies are at a slightly different potential from earthed bodies, and though it may be difficult to say exactly why they should be, the fact that they are is sufficient to account for the apparent miracle of self-excitement which characterizes nearly all induction machines.

Perhaps one of the most interesting suggestions arising from the experiment suggested above is in connection with the phenomena of atmospheric electricity. The effect of the movements of the books is so obviously suggestive of the influence which cloud masses must exert upon each other when one passes over two, with an intervening space to separate them, that there is no resisting the conclusion that in the phenomena of the thunder storm we frequently witness on a large scale an almost precisely similar experiment of Nature to that which we have been performing on the dining-room table with the three books to represent the cloud masses. Especially suggestive is the flashing of the sparks from one of the lower plates to the other, which occurs, as already mentioned, when they are placed very close together every time the upper plate passes across them. Here undoubtedly we have the very counterpart of the phenomenon often observed in a thunder storm, when, drawn by the influence of some upper layer of moving cloud, the lightning flash darts across from one charged cloud mass to another in a lower stratum.

* Knowledge.

THE NEW COURSE OF CHEMICAL ENGINEERING AT COLUMBIA UNIVERSITY.*

By EDMUND H. MILLER.

THERE is a distinct demand for a chemist who combines with a solid knowledge of chemistry considerable familiarity with both mechanical and electrical engineering, a man who is able to look at any proposition or process from the standpoint of the engineer as well as from that of the chemist; a man who can fill at first an analytical position but who is, on account of his engineering knowledge, better fitted to become a superintendent than the man trained only in chemistry—in fact a chemical engineer.

It has often been said, and with truth, that it is impossible to make a man both a chemist and an engineer in four years, when it takes four years to make him either. It must be admitted at once that a much better chemical engineer can be turned out in seven years than in four. We need no new courses for this; the student graduates as an electrical or mechanical engineer and then, preferably after a couple of years of practical experience, returns to the university for the study of chemistry. Such a man has his engineering foundation, finds the need of chemistry by his factory experience, and brings to the study of chemistry a mature mind and an enlightened desire for knowledge. His work in chemistry should be emphatically a university course leading, after the courses in analytical, inorganic, organic, physical, and industrial chemistry, to research work, and finally to the doctor's degree. Such a man has had the best training for a technical chemist or chemical engineer, for he has had both the engineering and the practical carrying out of work on one hand and the three years' study of chemistry with research work to develop his ability for investigation, on the other.

There is, however, a powerful and practical objection to such a course—the expense. The problem to be met at present is to approach this ideal as nearly as is possible in a four years' course. Such courses have been established at the University of Pennsylvania, at the Massachusetts Institute of Technology, and elsewhere. The course which follows differs from these in many respects, the most important being that it is based on higher entrance requirements, viz., sixteen points by the examinations of the College Entrance Examination Board in the following subjects: algebra, geometry, and plane trigonometry, chemistry and physics with laboratory work, freehand drawing, English literature, composition and grammar, American and English history, French, and German. No time is devoted to these subjects after admission, so that the entire four years is given up to chemistry, engineering, metallurgy, mathematics, mechanics, physics, and mineralogy. It is only by starting with these high entrance requirements (for the details see the pamphlet of the College Entrance Examination Board) that enough time can be found for the subjects essential to the chemical engineer, so the course to be given next fall at Columbia University contains more chemistry and more engineering than any four years' course so far proposed.

A CLARIFIER FOR WINE AND BRANDY.

THE first clearing composition, called "Heins quick clarifier," consisted, according to Windisch, of two separate fluids and gelatine in leaf form. Solution No. 1 was composed of an aqueous solution of 6.419 grammes of anhydrous zinc sulphate slightly adulterated with zinc chloride in 100 cubic centimeters of water. Solution 2 consisted of 10.522 grammes of crystallized potassium ferrocyanide, also in 100 cubic centimeters of water. When these two solutions meet in the wine or brandy, a strong and voluminous precipitate of zinc ferrocyanide takes place, which carries all the other floating particles with it.

There is still an excess of potassium ferrocyanide and a good deal of sulphuric acid present in the filtrate, but no zinc. However, not an inconsiderable quantity of the zinc is held in solution by the natural acids of the wine, so that in one case at least there were found 36.3 milligrammes of zinc oxide in one liter of clarified wine.

A second wine clarifier, called Münters rapid clarifier, lightning, consisted also of two fluids, of which solution *A* consists of an aqueous solution of 4 grammes of anhydrous zinc sulphate, 1.26 grammes of isinglass, 0.1 gramme of salicylic acid, and 0.56 gramme of an organic acid in 100 cubic centimeters of water together with a heavy deposit of isinglass. Liquid *B* consists

* Abstract from the School of Mines Quarterly.

also of an aqueous solution of 3.2 grammes of potassium ferrocyanide and 6 grammes of potassium carbonate. In this case the excess of zinc is precipitated by means of the potassium carbonate. From the precipitate wine dissolves out considerable quantities of zinc.

The distillate resulting from the wine which has been separated from the precipitate is in both cases equally free from prussic acid. Since the clarified wine in both cases contains zinc, the process is not to be recommended, and the Münters formula is by all means to be avoided because of the presence of salicylic acid.—Zeitschrift für Untersuchung der Nahrungs- und Genussmittel.

THE EVOLUTION OF ESCAPEMENTS.

SECOND PAPER.

IN our issue of February 27, 1904, we presented to our readers the first paper on this subject, copiously il-

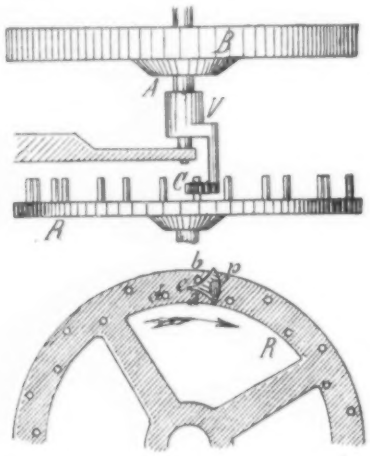


FIG. 1.

lustrated, dealing mostly with clock escapements. The present article is largely devoted to watch escapements. In taking up the subject again, the Almanach de l'Horlogerie says:

"The large number of observations, descriptions, and sketches which we have received, proves that our idea of describing the different escapements that have been contrived, both those for clocks and for watches, has been favorably entertained by our readers generally. It will, therefore, be possible to publish a long list of mechanisms more or less ingenious; of inventions, practical or incapable of use; of escapements which

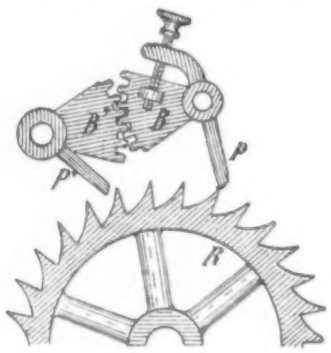


FIG. 2.

have given good results, or which, although never having been put into operation, are not the less interesting.

"It may be remarked that among the recoil escapements described in the previous paper, there are very few which have been applied to watches; almost all are clock escapements. The vertical escapement for watches, such as was represented in Figs. 1, 2, 3, was long considered as a piece of mechanism that could not be surpassed, and it may be a matter of surprise to notice the pains with which it was finally dethroned by the cylinder escapement. It seems, however, that it was rather the change in the arrangement of the mobiles which proved an obstacle, for as soon as the advantages of dead-beat escapements were recognized,

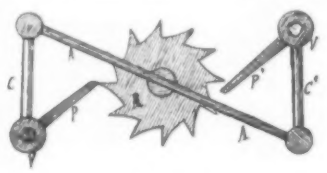


FIG. 3.

numerous systems came into existence, but with most of them the retention of the caliber in use was sought for; this was certainly one of the principal causes why the cylinder escapement was slow in adoption, notwithstanding its acknowledged superiority."

The accompanying Fig. 1 represents a recoil escapement for watches which is similar to the one for clocks exhibited in the previously published Fig. 15; the recoil is not as strong as in the ordinary vertical escapement, but the arrangement of the balance staff proved doubtless an obstacle to the regular working of this mechanism.

The escape wheel, *R*, is composed of a simple circle

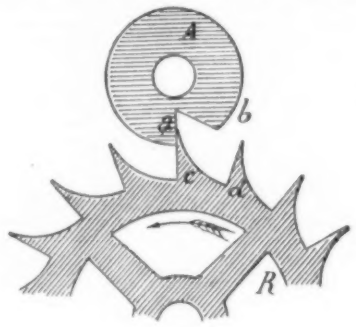


FIG. 4.

of brass, with the teeth replaced by thirty perpendicular pins; these pins act on a triangular piece, *p*, of which the two sides, *a* and *b*, act as pallets. This piece is fixed to a collet, *V*, adjusted on the staff, *A*, of the

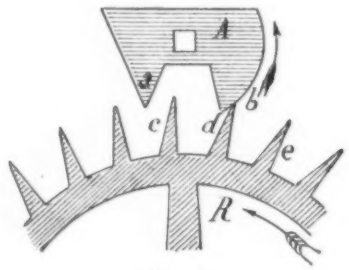


FIG. 5.

balance, *B*, and it is so placed below the staff that it turns round on its point, *c*. The impulse is communicated to the balance by the pins, acting in turn against the sides, *a* and *b*. In the figure a pin is seen in action

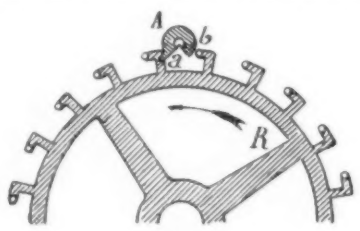


FIG. 6.

against the side, *b*; the wheel revolving in the direction of the arrow, the piece *p* will pivot around its point *c*, representing the balance staff. When the impulse is finished, the following pin, *d*, is locked against

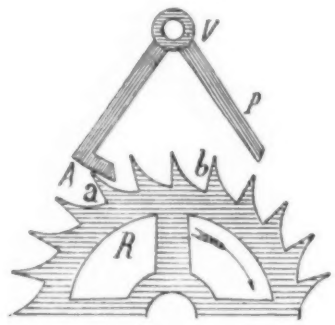


FIG. 7.

the side, *a*, but quite near the point, *c*, so that the balance, continuing its vibration, causes the wheel to recoil but slightly.

Before leaving the consideration of recoil escape-

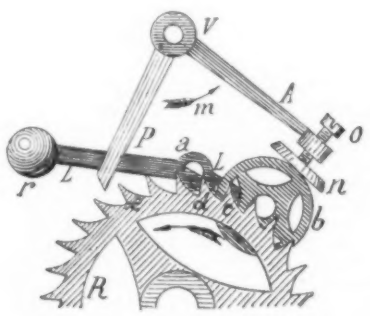


FIG. 8.

ments, we will give designs of two systems, which are only modifications of the double lever escapement, of which we have already given three models. It is seen that much attention was paid to this system, without in reality obtaining a substantial result.

Fig. 2 exhibits a two-lever escapement. The levers are solidly connected by two toothed arcs engaging together. An adjusting screw allows for the modification at will of the position of the levers with reference to each other.

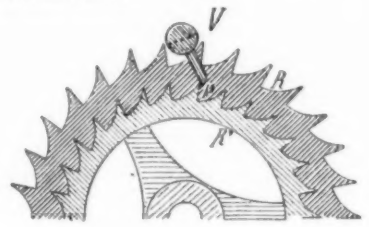


FIG. 9.

We have in Fig. 3 another double lever escapement, in which the pallets are connected in a different way. *V V'* are arbors carrying pallets, and one of them carrying also the fork which governs the pendulum. Two arms, *C C'*, solidly connected with the same arbors,

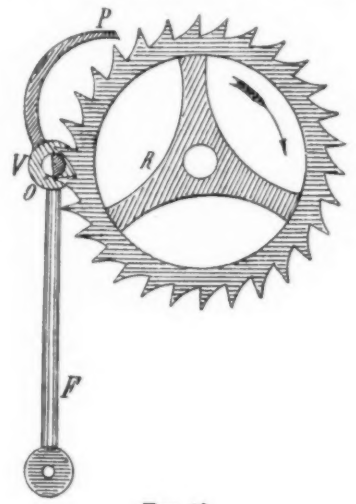


FIG. 10.

and thus participating in the movements of the corresponding pallet, have their extremities connected by a crosspiece, *A A*.

The working of these is easily comprehended, it being precisely similar to that of the other double lever escapements.

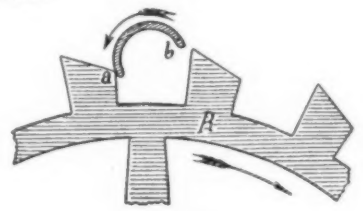


FIG. 11.

The superiority of the dead-beat escapements over the recoil escapements was admitted with great difficulty. The first dead-beat escapement was contrived in 1695; thirty years later, in 1725, Graham invented the cylinder escapement, and for more than a century

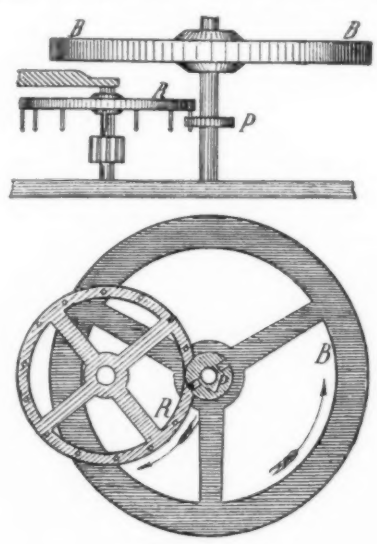


FIG. 12.

the recoil escapement continued in use, notwithstanding the appearance of the first detached escapement, about 1750.

While recognizing the qualities of the dead-beat escapements, especially the cylinder escapement, those of

the vertical escapement were still appreciated, and the effort was made by combining the two systems to succeed in nullifying the recognized imperfections of the latter and to avoid those attributed to the former.

For this purpose half-dead or half-recoil escapements were constructed, of which there were numerous models. We will describe a few. The collection may be enriched hereafter.

Several treatises on horology, speaking of the first

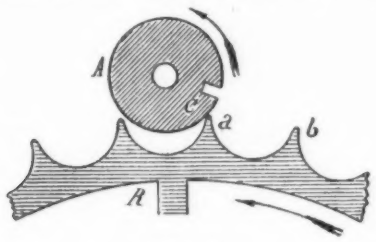


FIG. 13.

dead-beat escapement invented by Tompion in 1695, represent it as seen in Fig. 4. Now this is precisely one of the half-dead escapements. It is composed simply of a ratchet wheel, *R*, working with a disk, *A*, cut so as to form at *a* the plane designed for receiving the impulse. The tooth, *c*, gives the impulse on the lever, *a*, and the tooth, *d*, is locked against the circumference of the disk, *A*, which completes its oscillation. There is, therefore, no recoil at this moment, but on the re-

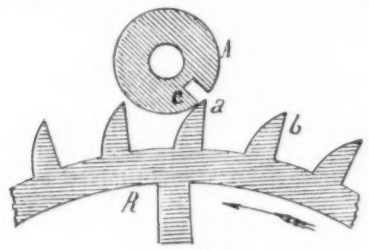


FIG. 14.

turn of the oscillation the tooth, *d*, penetrating the notch without producing an impulse, is stopped by the plane, *a*, which causes it to recoil before allowing it to effect its impulse.

This is the single-beat escapement, still employed in certain small clocks and in some alarms in the form represented by Fig. 5. It is so named because the balance or the pendulum receives impulse only in one direction; that is, during one oscillation in two. It is

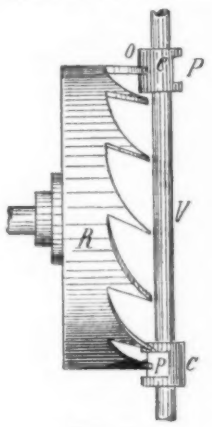


FIG. 15.

seen that the tooth, *d*, locked against the circular flanc, *b*, of the lever, can be disengaged only by the *vis viva* of the pendulum, actuating the lever in the direction of the arrow, and that no impulse is communicated; the tooth, *c*, undergoes, on the contrary, a recoil movement on reaching the lever, *a*, and it is only afterward that the impulse takes place, since it will be the turn of the tooth, *e*, to become locked against *b*.

This escapement causes much trouble for the watch-

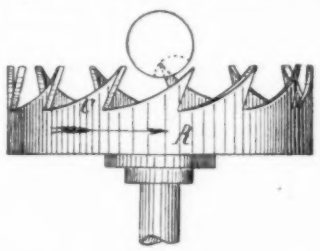


FIG. 16.

maker. It is generally employed with a light pendulum, which at times has not the necessary force to effect the disengagement when the spring is wound and the pressure of the tooth against the flanc *b* is quite strong. When the clock is nearly run down, it will stop from lack of force, and therefore is not a true dead-beat escapement, since there is recoil on one of the levers.

At the end of the year 1695 Tompion, in concert with Barlow, the inventor of the rack-striking arrangement, and another clockmaker named Houghton, patented the model of escapement represented in Fig. 6. We see here the same principle as that of Fig. 4; the teeth

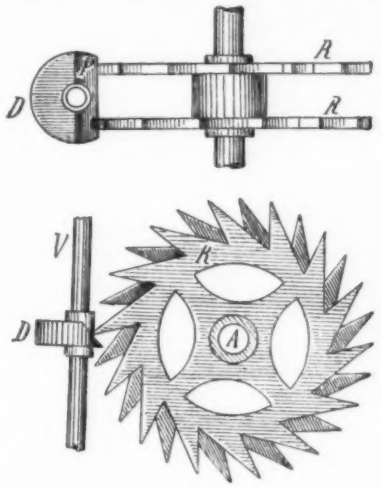


FIG. 17.

of the wheel project and the impulse lever, *a*, of the escapement piece, *A*, is lengthened. The rate of the watches furnished with this escapement was, it appears, but little influenced by the variations of the motive force, but one inconvenience decided Tompion to abandon this mechanism; the almost constant friction of the teeth against the roller caused a rapid wear of the balance pivots at the expense of the regularity noticed at the outset.

The principle of this escapement was utilized several

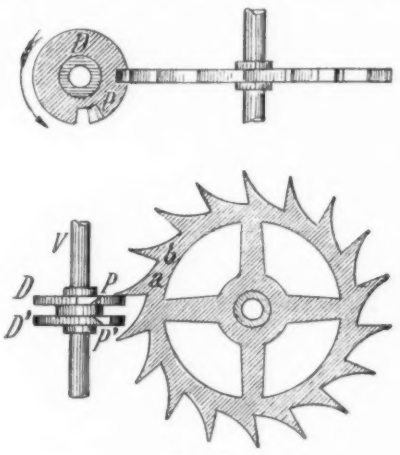


FIG. 18.

times under different forms in clocks. Fig. 7 shows us one of these applications. The lever, pivoted at *V*, carries on the right the pallet, *P*, which receives the impulse; and on the left the arm, *A*, serving to lock the teeth of the wheel. The tooth, *a*, is unlocked by the force of the balance, and the tooth, *b*, after recoiling, produces the impulse on the pallet, *P*.

Another mechanism, more complicated, is exhibited in Fig. 8. The locking and unlocking are operated by means of a special lever, *LL*, carrying at its pivoting

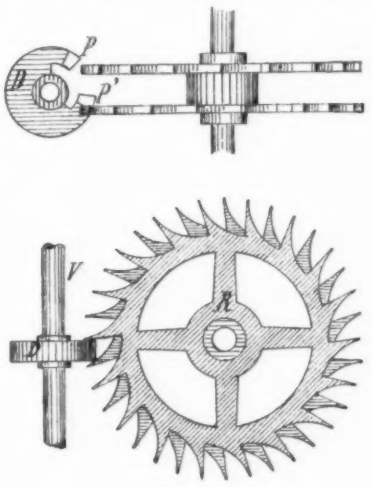


FIG. 19.

center, *a*, a semi-cylindrical stop-piece, against which the teeth of the wheel become locked. At the extremity of the right arm of this lever, pivots a roller, *b*, against the periphery of which presses a disk, supported by an adjusting screw, *O*, which passes through the extremity of one of the arms of the lever, *A*. The roller, *b*, is always in contact with the disk, *n*, and follows all its movements by means of the counterweight, *r*. The other arm of the lever is the pallet, *P*, which receives the impulse of the teeth. A tooth, *d*, is locked against the stop-piece, *a*, the balance terminates its vibration in the direction of the arrow, *m*, the arm, *A*, follows the same movement and the lever, *L*, turns on its axis, the counterweight, *r*, being lowered. The tooth, *d*, escapes, the tooth, *e*, meets the pallet, *P*, the

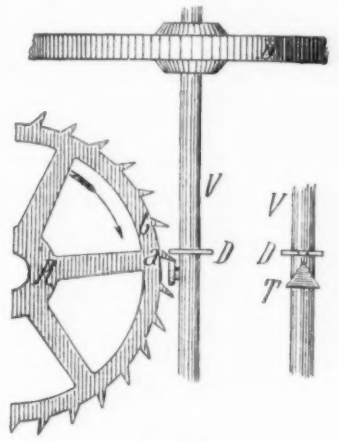


FIG. 20.

recoil and impulse follow, and it is the turn of the tooth, *c*, to be locked against the stop, *a*, which presents its cylindrical part after the pivoting of the lever, *L*, whose arm, bearing the disk, is lowered under the pressure of *A*.

Fig. 9 represents also a single-beat escapement, with pallet. There are two wheels of ratchet form; the teeth

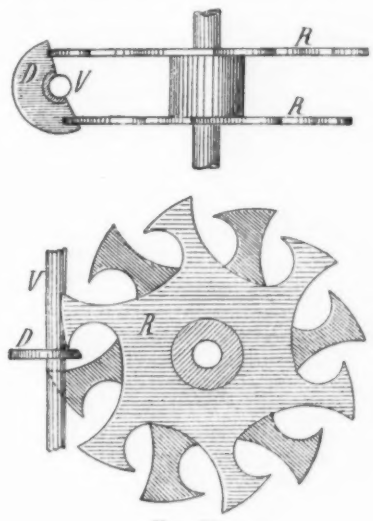


FIG. 21.

of the smaller, *R'*, give the impulse to the pallet, *P*, and those of the large wheel are locked against the arbor, *V*. The notch allows the passage of the tooth on the return of the impulse. This escapement was contrived by the clockmaker Dutertre, of Paris.

In the pendulum escapement seen in Fig. 10, which is due to Throut, senior, the locking is also produced on the arbor of the escapement piece, cut for allowing the passage of the teeth, which then give impulse to the pallet, *P*. The rod, *F*, transmits this impulse to the balance by the intermediation of the pin which is fixed perpendicularly to it.

The mixed escapement of Berthoud, represented in Fig. 11, is, like the preceding, alternately a dead-beat and a recoil escapement. Here, however, there is an impulse on the two sides. This mechanism holds a

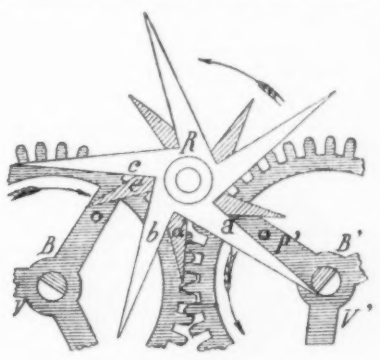


FIG. 22.

middle place between the escapement with pallet and that with cylinder. Its principal advantage lies in its simple execution, the wheel being entirely flat, and its teeth of a form easy to cut. The tooth, *a*, resting against the external surface of the cylinder, the latter continues its rotation in the direction of the arrow, as in the ordinary escapement. The rotation afterward taking place in the opposite direction, the tooth, fur-

nished with an inclined plane, produces the impulse, and is locked against *b*, the inside surface of the cylinder. But the lip, *b*, causes the wheel to recoil, and on the return of the balance the incline of the tooth causes its impulse on this part.

This escapement was employed by the clockmakers Duchemin and Robert. The first "remontoirs à cent sous," which were made twenty years ago in the Department of Doubs, were furnished with it.

We now come to the series of dead-beat escapements, that is to say, escapements in which the wheel has no recoil during the supplementary arc of the balance or the pendulum.

One of the first of these escapements must have been that represented in Fig. 12. There is no spring, and the balance turns continually in the same direction. Its staff carries a roller, *P*, having two notches, in which penetrate the pins with which the escape wheel is provided in place of teeth. These pins are locked against the edge of the roller, and at each half-turn of the balance one of them, penetrating one of the notches, produces the impulse, which keeps up the movement of rotation. It is evident that such an escapement could accomplish no important result, so we reproduce it as a curiosity.

We do not wish to contest the right of Tompion to the invention of the first dead-beat escapement, but as the one attributed to him and represented in Fig. 4 is only a half-dead escapement, we have every reason to believe that it was rather the mechanism shown in Fig. 13, which was really the first dead-beat escapement of Tompion.

This is the great wheel of the duplex escapement with its notched roller. This piece, *A*, revolving in the direction of the arrow, the notch, *c*, passes before the tooth, *a*, which is locked. On the return of the vibration, this tooth penetrates the notch and gives impulse to the roller. The next tooth, *b*, is afterward locked

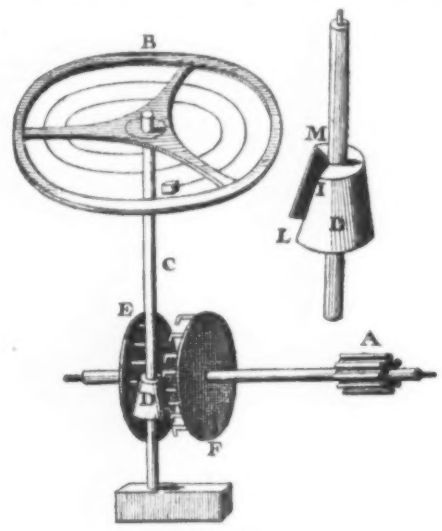


FIG. 23.

until the return of the following oscillation, when in its turn it penetrates the notch. This escapement is a single-beat escapement, like all the half-dead escapements. In consequence of the position of the point of the tooth against the roller, excessive friction is produced. The simplicity of its mechanism has, however, attracted the attention of investigators, but no important result has been secured. About fifty years ago an inventor endeavored to put it in practical operation, thinking that he could omit the escape wheel and work directly by means of the fourth wheel, whose teeth were formed as shown in Fig. 14. The astonishing variations which he obtained from one hour to another with this mechanism caused him to abandon it very speedily, as Tompion had a century and a half before.

The invention of the dead-beat escapement without recoil resulted immediately in the contrivance of a number of systems, among which we find the cylinder escapement. Notwithstanding the incontestable advantages of the latter, considering without doubt the difficulties at that period of producing the wheel and cylinder, and especially on account of the necessary change in the arrangement of the mobiles, there was an inclination to confine efforts to constructions that would permit of utilizing the caliber then in use. It was about 1760 that the horologist Lepine transformed this caliber, but still more than sixty years were necessary for the general adoption of the new arrangement.

Dead-beat escapements, in which the balance staff is perpendicular to that of the wheel, are numerous. We will speak first of the Flamenville escapement, Fig. 15, in which the ordinary vertical wheel is seen, not working with pallet, but with two cylinders concentric with the axis of the verge, and cut half through. The teeth of the wheel are locked alternatively on the periphery of these cylinders, and escape, effecting their lift on the plane formed by the cut portion, *PP*.

Fig. 16 shows us an escapement which differs very little from the preceding. Instead of the notches, there are simply two circular cavities in its arbor. The teeth of the wheel work against the sides of these cavities.

In 1700 Nicolas Fatio de Duillier, a Genevan, discovered the method of perforating and working the ruby and other hard stones. He proceeded to England to exploit his invention, and associated himself with Baufre, a French horologist, for the purpose of constructing watches, making use of this discovery. The pivots of the balance and of the escape wheel of these watches turned in perforated rubies. A certain number of these pieces were furnished with the escapement represented in Fig. 17.

The balance staff, *V*, carries a small hardstone roller, *D*, cut with inclined plane from its diameter. The escape wheel, *R*, is double, and the teeth are alternatively locked on the surface of the disk, then communicate the impulse, sliding over the inclined plane, *P*. The thickness of the roller is a little less than the interval between the points of the teeth, each point of one of the wheels corresponding exactly with the center of one of the spaces. These watches gave, it appears, quite satisfactory results.

Sully, the celebrated English horologist, who passed the greater part of his life in France, contrived in 1721 another arrangement of the Baufre escapement. He used a simple wheel, and two rollers instead of one; each of the two had a notch with inclined plane, designed for receiving the impulse. Fig. 18 exhibits this arrangement, of which the working is very simple. The tooth, *a*, is locked on the upper disk, *D*, which turns by the force of the balance spring in the direction of the arrow. At the moment when the tooth meets the inclined plane, *P*, it gives the impulse and becomes locked on the lower disk, *D'*. On the return of the vibration, the same tooth passes on the inclined plane, *P'*, and the next tooth follows in its turn in the same manner.

In 1736 a horologist named Enderlin produced another combination. He took the double wheel of Baufre and the two inclined planes of Sully, but arranged the inclined planes on the same disk. It is seen by Fig. 21 that its difference from the system adopted by Fatio and Baufre is not material. The two inclined planes are simply cut in a different direction.

Another arrangement, of which we do not know the author, is represented by Fig. 20. The wheel is simple, the lockings are effected on a thin disk, *D*, borne by the balance staff, *V*. A triangular piece, *T*, fixed on the staff below the disk, is designed to receive on the two sides alternatively the impulse of the teeth, which escape in turn from a notch carried directly by the disk above the upper angle of the impulse piece. In our illustration the tooth, *a*, is commencing its impulse, and the tooth, *b*, is about to be locked on the disk. On the right of the principal figure, a front view of the balance staff is presented.

This class of escapements yielded but mediocre results, and they were quickly abandoned. They had fallen into disuse, when, about 1830, M. Paul Garnier revived them, introducing a modification, which was quite successful. He preserved the double wheel, but caused the teeth to carry the inclined planes. The disk was very thin, and the impulsions were communicated against its edge on each side of the staff. Garnier combined this escapement, taking as a base the principles of the cylinder escapement. He gave to the teeth of his double wheel the same incline as that of the teeth of the cylinder wheel. The edge of the disk, having the same opening as a cylinder, had the form of the cylinder lips. According to him, the only difference consisted in the fact that in this escapement the locking occurred on the horizontal plane of the disk, and the effort on the end of the lower pivot of the staff, while in the cylinder escapement the locking is produced on a surface concentric with the staff, pressing the pivots against the sides of their holes.

Fig. 22 presents a watch escapement having some similarity with the pendulum escapement represented by Fig. 9 of the previously published paper. The latter belongs to the recoil system, while that which we will describe is dead-beat. Their resemblance consists in this, that the two balances and the two pendulums are connected together solidly by gearing, and each carries an impulse pallet or pin. The mechanism shown in Fig. 22 works as follows: The escape wheel, formed of two five-armed stars, fixed on the same arbor, is locked by the tooth, *a*, against the staff, *V'*, of the balance, *B'*, which turns in the direction indicated by the arrow. This staff, cut from its diameter, allows the tooth, *a*, to pass. At this moment the tooth, *e*, of the small star, reaches the pin, *P*, of the balance, *B*, and communicates an impulse, which is terminated by the locking of the tooth, *c*, of the large star against the staff of the balance, *B*. The two balances, of which one is furnished with a spring, terminate their oscillation in the same direction. At this moment the tooth, *c*, escaping, the tooth, *d*, effects the impulse on the pin, *P'*, of the balance, *B'*, and the tooth, *b*, is in its turn stopped by the staff, *V'*.

This escapement is the invention of Dutertre, the French horologist, and it dates from 1724. According to its author, it was but slightly affected by shocks, but it must be presumed that the friction of the gearing of the two balances was a defect more serious than the one sought to be avoided. However it may be, this mechanism gave birth to the duplex escapement, of which the form now known is due to Pierre Leroy. In termination, we reproduce in Fig. 23 a design which we have found in the "Collection of Machines and Inventions," approved by the Royal Academy of Sciences, which exhibits to us an escapement exhibited in 1742 by Pierre Leroy. It may be seen that this is a mechanism of the class of those represented in Figs. 17 to 21, and its working can be immediately understood. There is a double wheel, *E F*, bearing pins terminated by a hook. The extremity of the hook causes the locking on the upper face, *M*, of a truncated cone, *D*, of which an enlargement is seen at the side of the principal figure, and which is fixed on the staff, *C*, of the balance, *B*. After having accomplished their locking, the pins act alternatively on the inclined plane, *I L*, and this occasions the vibration of the balance. The design, which we have reproduced from curiosity, as we find it, is not well executed; for, according to the description accompanying it, each of the parts of the double wheel has only six teeth or pins, placed alternatively. A fact which should be noticed is that in general the horologists who have presented a dead-beat escapement, after the invention of the cylinder escapement by Graham in 1725, have always striven to demonstrate the inferiority of the Graham system, while recognizing its qualities.

In the description of the Leroy invention we read these words: "This escapement, applied by M. Leroy to a watch which he has sent to London, has the same properties as the ingenious dead-beat escapement of M. Graham, made use of by many clockmakers, with this difference only, that the escapement of M. Leroy has less friction than that of M. Graham."

The first watch made by Leroy with this escapement was ordered of him by M. Villeneuve, a Frenchman, engraver to the King of Portugal, and to the Lisbon Academy, on the occasion of "a wager of one hundred gold coins, or three thousand French livres," made with Englishmen on a comparison of French and English watches. The report states that the Leroy watch sustained the competition with one of the celebrated Graham so well that it was impossible to decide which was the best.

Notwithstanding everything, the cylinder escapement has remained the victor, and if the day can be foreseen when it will be supplanted in ordinary watches by the detached lever escapement, it is no less certain that this day is not very near.

UNDERGROUND TEMPERATURE.*

By JAMES STIRLING.

IN 1898 the writer made observations of temperature at different levels in the deep mines at Bendigo, especially in the mine known as "The 180," then the deepest in the district. The observations were made in slate, sandstone, quartz veins, and limburgite dikes, down to a depth of 3,250 feet. At the 180 mine the increase of temperature, from a line of no variation (about 80 feet from the surface), was as follows:

454 ft. was 1 deg. F. for every 100 ft. in depth.
1,294 ft. was 1 deg. F. for every 182 ft. in depth.
1,750 ft. was 1 deg. F. for every 173 ft. in depth.
2,295 ft. was 1 deg. F. for every 152 ft. in depth.
2,701 ft. was 1 deg. F. for every 137 ft. in depth.
3,110 ft. was 1 deg. F. for every 110 ft. in depth.
3,250 ft. was 1 deg. F. for every 111 ft. in depth.

Assuming that the mean of these was the average increase with depth, we get 1 deg. F. (or 243 feet for 1 deg. C.) for every 135 feet. The difference in temperature of the different rock substances at similar levels was almost inappreciable, except near fault lines.

In 1899 further observations were made in the deepest mines, the object being to prove that the heat of the rocks does not preclude mining operations at even 4,000 feet in the Bendigo district, because, if the recognized formula were accepted, we should have a temperature of 125 deg. F. at the 3,500-foot levels. Observation shows that such a temperature is not reached.

The assertion sometimes made, that mining might extend to as great a depth as 10,000 feet, if haulage could be accomplished, is untenable. The difficulties would not be in haulage, but: (1) that of breathing under the enormous atmospheric pressure; and (2) increase of temperature. A mass of air in a down-cast shaft, of 60 deg. F. at surface, at a depth of 10,000 feet would attain a temperature of 90 deg. by its own weight. It is possible to imagine a limit of 5,000 feet as a workable depth at Bendigo; but healthful mining, even at that depth, would be hardly possible, if the gain should be as supposed.

The summary of recorded results is as follows:

Locality.	Feet Required for Rise of 1 deg. C.
Calumet & Hecla (Agassiz)	402.6
Bendigo "180 Mine" (Stirling)	243
Maldon (Jenkins)	145
Ballarat (Jenkins)	144
Bendigo (Jenkins)	130
Someurty	118
Schladebach	114
Pittsburg	111
Spirenburg	105
Ruhr Coalfield	92
Saarbrucken	90

The mean result of the above would be 1 deg. C. for every 154.5 feet in depth. Excepting the abnormally low results at Calumet & Hecla, the accepted formula of 1 deg. F. for every 60 feet (or 108 feet for 1 deg. C.) in depth in the majority of the European and American localities, can no longer be maintained, as far as Victoria is concerned.

NOVEL ALARM WATCH.

AMONG the devices shown at the exhibition of mechanical toys and similar devices recently held in Paris, although many are too useful to be classed as toys, was an "alarm watch," whose bell is contained in the stand on which it is hung at night, and with which it is electrically connected.—Cosmos.

* Abstract from Monthly Report, Chamber of Mines of Victoria, October, 1904.

SCIENCE NOTES.

It is reported that the bacteriologists of the Pasteur Institute in Paris have at length succeeded in isolating the microbe of the tsetse fly, the brown insect which has wrought such widespread havoc in South Africa, both among human beings and animals. Hitherto all efforts to circumvent it have been fruitless, and if this discovery renders possible any means of rendering cattle and horses immune from the fly, a great benefit will have been extended to civilization in that sub-tropical country, and a desired impetus imparted to its commercial development.

Of all the forces that shall revitalize and recrystallize the country, the school is the chief. The schools make the opinions of the nation. The city school has been developed, but the country school has been relatively stationary; yet every farm family is interested in the school. The farmer believes in schooling, just as completely as the city man does; but he may not be convinced that the schools are really touching the problems of life. Persons make more sacrifices for their children than for any other cause. Probably more persons leave the farm to educate their children than for all other causes combined.

Determination of Sulphur in Coal and Coke.—The Eschka process has been modified by R. Nowick. The German technical periodicals give the modified method as follows: One gramme of the coal or coke, finely pulverized, is mixed with 2 grammes of carbonate of soda or of magnesia in a platinum crucible by means of a platinum wire. A vertical canal is formed through the middle of the mass, and the lower part of the crucible heated to the dark red. Oxygen is introduced through the crucible cover (Rose crucible) and the mass mixed together every five minutes, the central canal being each time re-established. After twenty or thirty minutes, the combustion is completed. The contents of the crucible are treated with water, heated, filtered, acidified slightly, precipitated with barium chloride, and the percentage in sulphur deduced. The period of the operation is from three hours to three hours and a half.

Prof. Jacques Loeb announces in a bulletin of the University of California his final experiments on the fertilization of sea urchins' eggs by chemical means. His latest work has been to form membrane in the eggs in the same order that it is formed in real life. Under natural fertilization this membrane is formed immediately after spermatozoon enters. The method of procedure is to treat eggs with a solution of fatty acid—acetic, propionic, butyric, or valerianic—mixed with fifty centigrammes of sea water. The eggs remain in this solution from one-half to one and a half minutes. When transferred back to the sea water they form membrane which cannot be distinguished from the membrane of fertilization. The eggs remain in normal sea water for five or ten minutes and are then put into a mixture of sea water and salt solution for twenty to fifty minutes. When taken out and placed in normal sea water again the formation of micromeres occurs as in normally fertilized eggs, and the rate of segmentation and development is precisely the same. The blastula cavity forms in these eggs as early and in the same way as in fertilized eggs and blastulæ begin to swim and rise to the surface as early as those developing from fertilized eggs. When the larvæ which rise to the surface are collected and kept in a watch glass it is difficult to distinguish them from larvæ produced from fertilized eggs. Thus Prof. Loeb has exactly duplicated the natural processes in the creation of life in sea urchins.

There is not a State in the Union which has not reported difficulty from algal growths in water, and in some communities the odor and taste during certain months of the year have rendered the water absolutely unfit for use. In a few cases the strong odor has even necessitated the giving up of the use of the water for sprinkling the streets and lawns. One water commission in New England considered the trouble due to algæ of so much importance that they were willing to expend about four million dollars upon devices, by no means certainly effective, in order to try and prevent such difficulties. A city in the far West spent over one million dollars securing new sources of supply so that the algal-polluted reservoirs might be abandoned. In the South we have a case where the algæ led the local authorities to take steps to cause the franchise of the water company to be forfeited, on the ground that they were not furnishing a potable water. The company had spent thousands of dollars in mechanical filters and other devices, without results, and there was no alternative but to install a new supply at a cost of double the one already in use. It is needless to say that a question of so much financial importance has been investigated exhaustively from the so-called practical side, and various recommendations made, all of little or no effect. Finally, the difficulty was relegated to the botanists, who took hold of the problem from the purely scientific standpoint and showed how certain plants were the specific cause of the trouble. It was then a comparatively simple matter, by applying the knowledge gained years ago by Naegeli and others in botanical research, to find a remedy for the difficulty. The only wonder is that it was not thought of before. Within the last six months the method of destroying or preventing the growth of algæ in water supplies, as devised by the Department of Agriculture, has been used with marked success in over fifty water supplies throughout the country, on a scale running into the hundreds of millions of gallons, and causing a saving in money difficult to estimate.

ELECTRICAL NOTES.

The use of electricity for cleaning purposes has been considerably developed during the last year or two, as we are familiar with the vacuum cleaning apparatus, which in most cases is driven by an electric motor, but it ought to be within the power of the designer of electrical novelties to produce electrical cleaning apparatus of a simpler character which would be within the reach of all of us who have the electrical supply in our houses.

We have such consistent accounts given by truthful and competent observers of balls of fire moving slowly in the air or rolling along the ground, sometimes attended with slight noise or explosion, in others by violent disruptive effects, that we cannot refuse to believe that ball lightning is a reality. It has been asserted that they do not really exist, but are merely persistent effects on the retina produced by a previous brilliant discharge; but as Planté in his researches has distinctly stated that he was able to reproduce ball-lightning effects on a small scale when experimenting with direct currents of high electromotive force obtained from his accumulators, there can be no doubt that nature does produce these phenomena for which at present we have no explanation to offer.

There appear to be three hypotheses of the cause of terrestrial magnetism, the first being that the crust of the earth has at some time, probably shortly after solidification, become a permanent magnet owing to the circulation of electric currents which possibly may have been produced by thermal causes. The second being that the cause was originally, and may still be, connected with the earth's rotation, which has gradually accumulated its magnetic field much as is the case with an ordinary self-exciting dynamo. The third hypothesis being that the sun itself is the power-station for the whole solar system, and that each of the planets is merely a distributing station for the energy generated in the sun. It can, however, be shown that the direct magnetic effect of the external field produced by the sun must be small, although we know that changes taking place in the sun are unquestionably associated with the appearance of the magnetic storms which are of such importance to the navigator and the telegraphist.

The problems of lightning discharges have from the very first interested us, and in these later days of large power schemes, the importance of protecting our works against lightning stroke has become increasingly evident. For a long time we thought that the damage caused by lightning was confined to systems of overhead conductors, as its effect on these was at once evident, in some cases by complete destruction of parts of our circuits, in others by the breakdown of our insulation, but during our recent developments of large-power schemes, employing systems of conductors to carry the energy into districts where the use of overhead conductors is inadmissible, the influence of lightning discharges, or of earth strokes connected with them, on our underground systems, has been undoubtedly the cause of many failures and interruptions to service, the investigation of which forms a problem of the first magnitude. The problem has been insufficiently investigated, but it appears probable that many of the mysterious perforations of the insulation of our underground cables are commenced by static charges due to condenser effects produced on a gigantic scale in the system.

Arrangement of Aerial and Ground Connections in a System of Lightning Rods.—The different rods are connected together on the roofs of the house. The rods situated on the gables, and on this account more exposed to the action of lightning, are always each provided with a separate conductor, one conductor to every two rods being sufficient in the case of those lower down. A conductor consists either of a copper wire 8 to 10 millimeters thick, or of copper wire rope containing seven wires 3.3 millimeters each in diameter. Only electrolytically pure copper should be used. Galvanized-iron wire cable, 15 millimeters thick, composed of twelve single wires 3.3 millimeters in diameter, is also employed. Large metallic bodies in the interior of the building, such as iron girders, iron pillars, rain, gas, and water pipes, metal roofs, etc., should be brought into good conducting connection with the conducting rod by screws and soldering. The object of the ground connection is to conduct the lightning to the earth with the least possible resistance. For this purpose copper plates 2 millimeters thick and from 0.5 to 1 square meter in area are generally employed. If there are more than two ground plates to one conductor, the size of the plates can be reduced to 33 by 100 centimeters. Galvanized-iron plates 1 square meter in area and 5 millimeters thick, iron rails, water mains (when allowed by law) can also be used for ground connection. The plates should be fixed in underground water, and far enough to remain covered when the water is at its lowest. If there is no ground water available, the electrode should be fixed in the moistest soil possible, e. g., in the neighborhood of rain spouts, kitchen drains, etc. In this case the surface of the electrodes must be doubled. Instead of solid ground plates, copper or iron wire netting may be used, but in selecting the size, care must be taken that they present the same conducting surface as the solid plates, i. e., one square meter. If the ground plate has to be placed in a well from which drinking water is taken, a galvanized-iron plate or galvanized-iron wire rope must be used, or the copper plate and connecting wires well tinned, on account of the poisonous character of the salts formed on the copper conductors.—Der Metallarbeiter.

ENGINEERING NOTES.

A ship of interest to marine engineers has recently been launched in England. This is the British India turret-deck steamer "Queda," which has a total deadweight capacity of 12,000 tons, a cargo space of 690,000 cubic feet, and water ballast tanks holding 4,000 tons. It has long been maintained among shipbuilders that a ship of more than 6,000 tons built upon the single-deck principle could not be constructed with safety, but the "Queda" has demonstrated the practicability of building a single-deck steamer of such tonnage.

The extensive shipbuilding yards of Harland & Wolff at Belfast (Ireland) have been equipped with a massive new gantry built by the Brown Hoisting Machine Company, of Cleveland, Ohio. It has a length of 600 feet from end to end. The double cantilever crane, which extends 102 feet on either side of the gantry, and can thus serve any part of the ships building on the two slips, will take loads up to five tons, and has a length of 230 feet over all. Its rate of longitudinal travel is from 400 feet to 600 feet per minute, varying according to the load and wind pressure. The rate of cross travel ranges from 400 feet to 300 feet per minute. The hoisting speed is from 200 feet to 250 feet per minute with the maximum load. The crane is driven by a single electric motor with reversing clutch. This crane is supplemented by two side cantilever cranes for taking heavy riveting machines, each with two bridges traveling at 20 feet per minute, and each with a handling capacity of 10 tons, and a hoisting speed ranging from 10 feet to 16 feet per minute.

Boilers are of various sizes and shapes, and arranged so that the gases flow in more or less contact with them, by paths of more or less length. Now, as the purpose of the boiler in this connection is to abstract heat from these gases, it must be true that the various shapes and gas passages, which are fixed features of the mechanical construction, have an influence on the amount of heat flowing to it. Therefore, this metallic structure, because of features of shape and arrangements of its parts, does necessarily produce an effect, and whatever such effect is, it is fixed and permanent, because it is due to the mechanical arrangement which cannot change, and this is what the author designates as efficiency of a boiler. Other influences may act in conjunction with it, and thereby produce a different result, but this does not change this feature of efficiency of the boiler; it is permanent, and can no more change than the mechanical form and construction. For example, if a good boiler becomes scaled and dirty, this latter influence will produce a new and inferior result, but let another inferior boiler become scaled and dirty, such influence will be the same for each. Likewise a poor fire under a good boiler will produce a poor efficiency, caused, not by the boiler, but by the fire itself; and the same poor fire under an inferior boiler will result in a lower efficiency than with the better boiler.

Use of Residual Products of Petroleum for Fuel in the Russian Navy.—When the first attempts were made to employ petroleum for fuel on board the "Puebla," Deville made use of inclined grates with grooves in which the liquid was allowed to flow, and this method was also for a long time in vogue in the "Caucasus." The Russians now use a simple but imperfect spray system. The apparatus consists of a burner in the shape of a square point, and the lighted petroleum issuing from this burner is brought into contact with a jet of steam, which forces it through variously directed slits. In this manner a flame 1 meter long and 50 centimeters broad is produced. Since 1874 this method of heating with petroleum has become nearly universal on the Volga, the Caspian Sea, and on the railroads in those regions. Comparative experiments made in these districts have shown that by the use of petroleum in place of coal a saving of 49 per cent in weight and 61 per cent in expense can be effected. The largest petroleum heating plant was seen in Chicago, where 52 boilers developed a force of 52,000 horse-power. All the attention necessary was supplied by two firemen, whose duties consisted in the occasional adjustment of slides and valves. An overseer was stationed at a post of observation to watch for any smoke, and any boiler from which smoke was seen to arise was at once indicated on an electric signaling apparatus, the smoke being then immediately stopped. This plant has, however, been surpassed in many respects by the steamers on the Caspian Sea, in which the necessity for special attention to the heating apparatus is entirely dispensed with. The heating room immediately adjoins the engine room, and the boilers are placed in full view of the engineer, who can readily regulate the steam pressure as may be required. The Chicago boilers were fitted up in the same way as coal boilers with large furnaces, except that they had a fireproof lining. There is also a mixed system, which has been employed for the last three years in the Italian torpedo boats, and which consists in conveying petroleum spray on to a glowing layer of coals in an ordinary hearth. With an increased draft this system is very serviceable when great power is required, e. g., when it is necessary to pursue or escape from an enemy, or when a locomotive has to ascend a very steep gradient. The supplies of "masut" at present available are limited and comparatively expensive, and large ships are obliged to have recourse to mixed heating. In addition to the Russian "masut" and the heavy American oils, there are large supplies of naphtha which have hitherto not been opened, as they contain only a small quantity of oil suitable for lighting purposes, but yield much heavy oil.—Der Metallarbeiter.

TRADE NOTES AND RECIPES.

Cement for Waterpipes.—A mixture is formed, hot, of linseed oil, 3 parts; colophony, 10 parts; quick lime, 10 parts; carded cotton, 10 parts.—Practicien.

Anti-rust Preparation.—Tallow, 25 parts; white wax, 23 parts; olive oil, 22 parts; oil of turpentine, 25 parts; mineral oil, 10 parts. Mix the different ingredients at their average fusing temperature, stirring constantly.—Les Corps Gras.

Mixture for Removing Spots from Fabrics.—This formula is suitable for industrial use. Water, 500 grammes; sulphuric ether, 10 grammes; soap powder, 10 grammes; spirits, 15 grammes; oil of turpentine, 30 grammes; ammonia, 10 grammes. The whole should be mixed carefully and shaken until a homogeneous liquid is secured.—Polytechnisches Journal.

Resin for Soldering.—The following compound is said to be particularly adapted to soldering on bright tin: Mix 675 grammes of olive oil, the same quantity of tallow, and 360 grammes of pulverized resin, and boil. When the mixture has cooled, add 700 to 720 grammes of water, saturated with pulverized sal-ammoniac, turning constantly.—Science Pratique.

Remedy for Chapped Hands.—Gum tragacanth, 3 parts; rose-water, 435 parts; glycerine, 31 parts; alcohol of 90 per cent, 31 parts. Macerate the gum in the rose-water for a few days, until it can be passed through a piece of muslin, and then add the glycerine and alcohol. Wash the hands well, then rub on the skin as needed.—Parfumere et Savonnerie.

Gutta-percha Cement.—Mix intimately in an iron receiver 2 parts of black pitch with 1 part of gutta-percha; pour the whole into cold water. The product soon becomes black, elastic, and solid, and will soften at a temperature of about 50 deg. C. It may be employed in the pasty or liquid state to unite metals, glass, porcelain, and ivory. It serves also for fastening panes of glass in windows, aquariums, etc.—La Nature.

Lubricant for Belting.—Dissolve 2 grammes of caoutchouc cut in small pieces in 2 grammes of rectified oil of turpentine heated to 60 deg. C. Add immediately 1 kilogramme of ceresine, or ½ kilogramme of paraffine. In another vessel heat 5 kilogrammes of fish oil and 2 kilogrammes tallow, and when the whole is melted and well mingled, add slowly the solution of caoutchouc and ceresine.—Science Pratique.

To Prevent Lamp Chimneys from Breaking.—Put them on the fire in a vessel filled with cold water, add a little coarse salt, boil and then cool slowly. This process may be applied also to objects of crockery or porcelain. In this way the objects are annealed, and the slower the operation, especially in the cooling of the water, the stronger will they become. If a glass chimney is cut with a diamond on the convex side, it will not break, for the cutting facilitates the dilatation produced by the heat.—France Horlogère.

Artificial Rubber.—Mix 5 per cent of Auvergne bitumen with Manila gum; dilute with benzine and triturate well; add 5 per cent of resin oil, and allow an interval of two days after each manipulation. A product is thus obtained which has the flexibility, malleability, and elasticity of caoutchouc. If the mixture is too fluid, add 4 per cent of sulphur dissolved in carbon sulphide. To secure a perfect product, 5 per cent of caoutchouc may be added. The product may be vulcanized by the usual process.—Formulaire.

Method of Attaching Glass to Metal.—The following are various receipts for this purpose: (1) Melt together 160 grammes of finely pulverized colophony, 40 grammes of white wax and 80 grammes of English red stuff, add to the liquid mass 20 grammes of oil of turpentine; remove from the fire and stir the whole constantly with a wooden spatula until cooled. (2) Cement the heated parts with good sealing wax, not brittle; ordinary sealing wax may be put into good condition by adding a little turpentine. (3) Mix equal parts of shellac and very finely pulverized pumice stone; apply hot. (4) Mix 10 parts of resin-pitch with 1 part of white wax; attach the glass with the mass thus formed.—Science Pratique.

Cement for Stone, Porcelain, etc.—Under the name *scioliao*, the Chinese make an excellent cement for fastening stone, marble, plaster, porcelain, and crockery. It is composed of powdered spent lime, 54 parts; pulverized alum, 6 parts; fresh blood well beaten, 40 parts. The whole is stirred vigorously until there is secured a perfectly homogeneous mass of cream consistency and of greater or less density, according to the purpose designed. When more fluid, it may be used as suitable covering for waterproofing and hardening. Two or three layers applied to cardboard render it as hard as wood. It is brown and lustrous. Fats do not attack it.—Chemiker Zeitung.

Cleaning of Copper.—The cleaning of some copper objects with powders or other substances is attended with difficulty on account of their worked and ornamented surfaces. Still, at times, success is complete, by means of acids. If the object is greasy, the grease must first be removed by a hot solution of soda, and then the object immersed in clear water. The bath designed for restoring brilliancy is thus composed: nitric acid, 2 parts; sal-ammoniac, 1 part; or else sal-ammoniac, 1 part; nitric acid, 1 part; and water, 1 part. The sal-ammoniac is to be dissolved in the water so as to obtain a saturated solution. The object should not be left immersed in the bath more than two seconds, and should afterward be rinsed, first in cold water, then in hot soapy water, and dried with warm sawdust.—La France Horlogère.

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